PAPERS,

CHIEFLY ANATOMICAL,

PRESENTED AT THE

PORTLAND MEETING

OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,

AUGUST, 1873.

By BURT G. WILDER, M.D.,

PROFESSOR OF COMP. ANATOMY AND ZOOLOGY, CORNELL UNIVERSITY, ITHACA, N. Y.

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CONTENTS.

THE OUTER CEREBRAL FISSURES OF MAMMALIA (ESPECIALLY THE CARNIVORA) AND THE LIMITS OF THEIR HOMOLOGY. By BURT G. WILDER, of Ithaca, N. Y.

NATURALLY, human brains have been most extensively studied, and chiefly those of adults; some have compared fœtal brains with those of *Quadrumana* but the existing doubt and disagreement,* with the lack of any generally recognized basis for the determination of fissural homologies, suggest the need of a different method of study; and as the main object of this and the next paper is to throw doubts upon the value of current opinions respecting brains, it is proper to state the materials upon which my opinions are based. It will be understood therefore that, unless otherwise stated, my present generalizations are based upon these materials only, and are subject to revision when a larger number of specimens is at my disposal.

Where but a single drawing or diagram was made, it generally represents the outer surface of the left side; the second usually the right side, or the upper (dorsal) surface; and the mesial and ventral surfaces were added if their peculiarities required and time permitted. All of these drawings and diagrams were made by myself, and most of them were exhibited at the meeting.

The varieties of dogs' brains will be given in the next paper.

On the following page I give a list of original preparations and drawings of mammalian brains made since July, 1871, and forming the basis of this and the following paper.

* A good example of this is stated by Ecker who includes the anterior central lobe with the frontal, while Gratiolet and Bischoff include it with the parietal.

This note, with some other matter which delay in publication has permitted me to insert, should bear date of December, 1873.

SCIENTIFIC NAME.	POPULAR NAME.	NUMBER OF INDIVIDUALS. FŒTAL.	YOUNG.	ADULT.	TOTAL.	DRAWINGS.	DIAGRAMS.
Homo sapiens	Man	5	....	1	6	8	3
Macacus	White-faced India Monkey	....	....	1	1	....	....
Cynocephalus	Baboon	....	....	1	1	....	2
?	Monkey	....	....	5	5	....	....
Canis familiaris	Domestic Dog	....	6	23	29	58	22
Canis occidentalis	Gray Wolf	3	....	....	3	1	1
Vulpes fulvus	Red Fox	....	....	2	2	2	2
Felis catus, *var.* domesticus	Domestic Cat	5	17	20	42	4	4
Felis leo, *var.* Africanus	African Lion	....	1	....	1	1	....
Felis leo, *var.* Asiaticus	Asiatic Lion	....	1	....	1	5	1
Hyæna vulgaris	Striped Hyæna	....	....	1	1	3	1
Ursus Americanus	Black Bear	....	....	1	1	2	1
Procyon lotor	Raccoon	....	....	3	3	2	2
Putorius Noveboracensis	Weasel	....	....	1	1	1	1
Sus scrofa	Swine	19	4	1	24	....	2
Equus caballus	Horse	1	1	5	7	....	....
Equus	Mule	....	....	1	1	....	....
Bos taurus	Cattle	7	8	5	20	....	1
Ovis aries	Sheep	10	8	....	18	....	2
Capra ægagrus	Goat	....	....	1	1	....	....
Capra ægagrus, *var*	Cashmere Goat	....	....	2	2	....	....
Cariacus Virginianus	Red Deer	2	1	1	4	....	....
Camelus Bactrianus	Two-humped Camel	....	....	1	1	....	....
Mus decumanus	Brown Rat	....	....	2	2	....	....
Mus musculus	Mouse	....	....	2	2	....	....
Arctomys monax	Woodchuck	....	1	1	2	....	....
Fiber zibethicus	Muskrat	....	....	1	1	....	....
Sciurus Hudsonius	Red Squirrel	....	....	1	1	....	....
Cynomys Ludovicianus	Prairie Dog	....	....	1	1	....	....
Hesperomys leucopus	Deer Mouse	....	....	1	1	....	....
Scotophilus fuscus	Brown Bat	....	....	1	1	....	....
Didelphys Virginiana	Opossum	1	....	2	3	....	....
Genera, 28; Sp., 32; Var., 40-45.	Total	53	48	88	189	87	45

These specimens form part of a collection to illustrate the neurology and embryology of domesticated animals, which Professor Agassiz* authorized me to make for, and at the expense of, the Museum of Comparative Zoology in Cambridge.†

It will be seen that the above list of one hundred and eighty-nine individuals includes about twenty-eight genera, represented by about thirty-two species, and about forty-five varieties, the numbers varying according to differing estimate of the taxonomic relations of the individuals.

The size of human brains, the expense of their preservation in numbers, the rarity of apes' brains, and especially of fœtal specimens, together with the complexity of the fissural pattern which man and *Quadrumana* have in common with herbivorous mammals, are additional reasons for selecting other subjects. A simpler fissural pattern exists with the *Carnivora*. Among these the wild *Canidæ* (fox, wolf and fennec) occupy a position midway between the *Viverridæ* and *Mustelidæ* on the one hand, and the domestic dogs, the *Felidæ*, *Ursidæ* and *Hyænidæ*, on the other. That is, all the main fissures found in *Carnivora* are present in the fox, but uncomplicated by contortions and by secondary fissures.

METHOD OF PREPARATION.‡—The present paper treats only of those cerebral fissures which are visible from the outer *side* of a brain properly prepared. Heretofore all brains have been har-

* Since this paper was written, he who inspired it has finished his work in this world. As his student, his assistant and fellow-teacher, I cannot refrain from expressing my sense of bereavement. To me he was not only a great naturalist; he was the wisest of teachers and the kindest of friends; whose criticism was a healthy stimulus and his praise a sweet reward.

† Those who bear in mind that not a single brain was preserved from an entire menagerie which was suffocated in Boston about thirteen years ago, and that no similar collection exists in this country on account of its great cost in time, alcohol and means of displaying, will appreciate the extent of interest which Prof. Agassiz felt in this special undertaking; and while, as Professor in one institution, I must regret that the result of any of my work should leave it for another, yet as it must be years before my own or any other museum can command the means required for such a special collection, I am really grateful for the opportunity of using this material as it came for the instruction of my students, and by this kind of work, avoiding for a season, the outside drudgery in the way of popular writing and lecturing, to which the existing financial condition and policy of the average American University compel its Professors continually to resort, whether ready or not, to the impairment of their powers, and the detriment of the interests of the institution to which they would rather devote all their time, their energies and their enthusiasm.

‡ It may seem that these remarks might be omitted or placed at the end of the paper; but I have become so impressed with the often repeated dictum of Prof. Agassiz that "the method affects the result," that I wish to submit mine at the outset.

dened while resting upon their *base*. They become unnaturally flattened, and are then generally figured from *above* only. Like so many other methods borrowed from anthropotomy, the common manner of extracting the human brain is seldom applicable to those of animals; the skull, as well as the brain, is more useful if vertically bisected, and this seems to be the only way of insuring the safety of the olfactory lobes and the *appendicular lobule* of the cerebellum; the former are rarely figured of their full size (as, for example, in the cat and cheetah. Trans. Zool. Soc., vol. i, pl. xx), while the very existence of the latter seems often unsuspected even in those animals where, by extracting the brain after bisecting the skull, I have found it of great size. In a future communication, I intend to illustrate this peculiar organ and make some remarks upon its connections, mode of formation, function and zoological significance. It is particularly large in the bear but small or wanting in the lion and in cats; being often bulbous at its extremity, the utmost care must be exercised to avoid breaking the pedicel, and I have found it easier to effect the dislodgment by throwing air behind it with a small blow-pipe. Figure 1 represents from below the left appendicular lobule (A L) of a Chinese dog;* it seems to be a protrusion of a portion of one of the horizontal series of convolutions.

I am inclined to think that in most cases, the way to preserve the entire brain in its natural form is to bisect it either before or after extraction, and to place each half upon its *mesial* surface in a flat-bottomed vessel of alcohol. As it rapidly loses weight in alcohol† and gains in water, and as handling out of these fluids is apt to distort it, I would recommend weighing each half of the head before and after extraction; the difference gives the exact weight of the brain; but as the apparatus which I employ (a sort of adjustable "Mitre-box") does not as yet enable me to insure bisection on the middle line exactly, I have not felt justified in comparing the two halves of brains together. If both hemispheres are to be preserved entire, the section should go rather to the left than the right of the middle line, in order to leave the mesial surface of the right hemisphere uninjured; but if the right is to be

* This and the other figures will be found at the end of next paper.

† The extent of this loss may be seen from the following cases; a brain weighing ,065. lost one-sixth of its weight in eighteen hours, and one-third in four days; a brain weighing ,125. lost one twenty-fifth in sixteen hours and one-half its weight in two months; of course the rapidity of the loss will vary with the size of the brain, the amount and strength of the spirit and the frequency of its renewal.

dissected, then the mesial surface of the left should be saved by carrying the section a little to the right; of course, however, if there is certainty of the saw going just between the two, so much the better.

The *pia mater* should be removed *before drawing;* this is best accomplished after the brain has shrunken a little in spirit, using a pair of fine forceps and fine curved scissors.

If possible, both sides of a brain should be drawn; but if only one, the left; and with all *Carnivora* (although not with all *Herbivora*), all the outer fissures may be seen in such a view; while this is not the case in the view from above, even when the brain is flattened. In drawing, each half should rest upon a slip ruled in square centimetres;* if the brain is larger than that of a cat, the slip may be pinned upon a sheet of cork, and two or more threads stretched over the brain, coinciding with the lines hidden by it; then the drawing may be made upon another ruled slip, with great accuracy; the mesial, upper and lower surfaces of the brain may be drawn in like manner, though less easily; and large diagrams may be accurately reproduced, by ruling cloth in squares ten, fifteen or twenty times the diameter of the original drawing; the homologous fissures may be uniformly colored as in the diagrams exhibited; Gratiolet, Owen and Bischoff have colored homologous *folds*, but it is obvious that the same end is more readily attained by coloring the fissures; and that alterations are also more practicable.

It would certainly be an advantage to possess a cast of the cranial cavity for comparison with the brain; and all comparative measurements and weights should take into account the shrinkage of brains, and their loss of weight.†

*I am happy to state that Mr. Geo. Woolworth Colton, the well known map-maker, and a member of this Association, has offered to prepare ruled paper of a size and quality suited to this and other natural history purposes.

It will be noted that the *perspective* is ignored in drawings made by the above method; each fissure is represented as if at a point on a line *perpendicular* to the surface on which the brain rests: a drawing in which this line should be perpendicular to the *convex surface* of the hemisphere would produce the effect seen in fig. 5, plate 1*a*.

†When a brain is once thoroughly hardened in alcohol it may be kept in weaker spirit or clear water during examination; it rapidly shrinks still more in the air; I am conducting experiments to show how well and how long, hardened brains can be preserved in a mixture of equal parts glycerine and water; which does not evaporate like spirit and, by its greater specific gravity, avoids injurious pressure of the specimens upon each other or upon the vessel; the best way of keeping many brains for study is in a wide tin box two or three inches deep and cased in wood, with a glass cover; if each half of a brain is kept on its mesial surface, no injury can result.

The Cerebral Fissures.— More attention has been given to the folds (gyri, convolutions, or anfractuosities) than to the fissures (furrows or sulci). But, whatever may be the manner of their formation, the latter really represent the location of the augmented gray, ganglionic or dynamic tissue more than the former; for, as a rule (the only exceptions being the points of oblique junction of two fissures), the contiguous walls of a fissure are nearer together than the two sides of either of the folds which it separates; a line representing the fissure, therefore, indicates the location of a much larger bulk of gray matter than a line of equal width representing any part of the surface of the fold.

Practically too the fissures are by much the easier to describe and designate, and it would be as hard to designate folds without first identifying fissures as to describe the countries of Europe without mentioning its rivers. The sides of a fissure are usually near together and parallel, so that the fissure may be described or figured as a single line of certain direction; but the opposite borders of any one fold are rarely parallel throughout their whole extent.

Moreover, the surface, which in one brain forms two folds, with an intervening fissure, may in another be one continuous fold. What shall it be called? Relatively, at least, the *surface* of a convoluted brain is the same as it was before the fissures appeared; while the fissures are gradually introduced and are to a certain extent capable of identification; and although they may be wholly due to a vertical elevation of the contiguous folds, yet it is the fissures and not the folds which can be said to increase, to connect, or to remain separate. Granting, then, that folds are the ultimate object of our study, fissures are first to be so thoroughly identified in all animals that when one of them or one of the folds is mentioned, there can be no doubt of its being recognized by all.

Fissures may be studied in four ways:

First: As to their general nature.

Second: Singly, as to their special peculiarities.

Third: As evidences of zoological affinities.

Fourth: As indications of intellectual power.

The last view will be considered in the next paper. According to the first view, we may at once separate three of Owen's fissures from the rest. The *rhinal* is the line of separation between the olfactory crus or tract and the cerebrum proper. The *median* or *inter-hemispheral* fissure divides the two cerebral hemispheres; and although in most *Carnivora* the true fissures seem to be arranged with some reference to it, and although it has clearly defined borders, yet neither of these features exists with *Herbivora*. The sylvian fissure marks the location of a kind of mound of cerebral substance, the "Island of Reil," and its manner of formation is somewhat peculiar, as shown hereafter.

Formation of Fissures.—No one doubts that all brains, even the most deeply furrowed, were smooth at an earlier stage of development. This transformation, so far as the result is concerned, might be compared with the segmentation of an undivided yolk; but probably the process is more often comparable with the formation of the primitive furrow; and although they look like clefts or depressions in the brain mass, it is probable that the fissures are the result of a difference in the rapidity of growth of different parts; certain points or lines remaining relatively stationary, and becoming the bottoms of depressions or fissures. Still I cannot rid myself wholly of the idea that shallow fissures, at least, may be formed by direct *depression;* and if Ecker is rightly translated he seems to have this view respecting all of them; "Actual convolutions are formed in these districts only with the further progress of the formation of fissures (p. 14). The formation of the convolutions is, of course, entirely dependent on the development of the fissures; and in the region of the temporal lobe, in which the latter are most variable, the convolutions are so too" (p. 65).

But on page fifteen, in contrasting the sylvian with other fissures he says that the latter "originate simply from *depressions or folds* of the cerebral cortex." (The italics are mine).

Now, as regards the aspect of the cerebral surface in the adult, it makes perhaps no great difference whether we speak of the fissures as depressions or the folds as elevations; and the former is more natural on account of the greater extent of the elevated surfaces; so too in conversation it is easier to say that the sun rises and sets than that the earth revolves upon its orbit; but in scientific language it would seem proper to speak according to the fact rather than the appearance.

Undoubtedly one source of confusion is the indiscriminate use of terms signifying the transformations themselves and the conditions reached thereby; and we might avoid it by discriminating between appearance and aspect, formation and conformation, development and presence or existence, etc.

As a single example of the looseness of our present expressions, on account of lack of definite information, Huxley (Comp. Anat. of Vertebrates, p. 492) enumerates among the distinctive features of the human brain, "the filling up of the *occipito temporal* fissure," as compared with that of apes; in its *most literal* sense this would imply that something *filled* a previously existing fissure; a little less literally, that the bottom of the fissure grew up to the surface of the adjoining folds, so that a fœtal fissure did not exist in the adult; and still again, and this would be a perfectly legitimate interpretation, it might indicate the fact, that a fissure which exists in apes did not exist in man in any stage; but even this would be capable of at least two meanings, according as the readers believed, or not, in actual evolution.

The formation of fissures seems to proceed very rapidly.* I have traced it in kittens of the same litter, killed at short intervals beginning at birth; and even allowing for individual and sexual differences, it would appear that during the first week, a change may occur perceptible within six hours; the most favorable fissure for this purpose is the *frontal.*

The large superficial cerebral vessels often lie in the fissures; but that this is merely a coincidence, and not a cause, is indicated by the frequent departure of these blood-pipes from their trenches; the slight furrow which marks the course of a large vessel across a fold has generally a more regular form with better defined borders. Where the folds are much contorted as in man and most herbivora, as compared with their simplicity at an earlier stage, one can hardly avoid the conjecture that the folds are formed under pressure, and that the brain behaves much as would a piece of thick cloth crowded into a cavity. Still more suggestive of this idea is the lateral contortion of the median lobe of the cerebellum in cats; in the newly born kitten (Fig. 2, K), this is vertical in direction and presents few folds; in all but one of the adult cats that I have examined, the median lobe appears, as in Fig. 2, C, laterally contorted; the progress of these remarkable changes will be fully illustrated on another occasion.†

* As does the yolk segmentation with Turtles (Agassiz, Cont. Nat. Hist. U.S. 2, 523).

† Ecker speaks (p. 10) of the "formation of convolutions as a necessary consequence of certain mechanical processes of the brain and skull," but it is not clear how much influence is attributed to the latter by this expression.

Yet while we may recognize a sort of *correlation* between the existence of fissures and the need of enclosing a certain amount of gray matter within a space which is represented by the cranial cavity, it by no means follows that osseous walls are the immediate and direct cause of the convolution; much less does it follow that the particular direction of the fissures is occasioned by the ridges upon the inner cranial surface with which they coincide. In short, we may regard the size of skull and of brain as concomitants of the degree and character of fissuration without attempting, as yet, to assign to them the relation of cause and effect. It may not be proper to compare cerebral fissuration with the primitive formation of the encephalic lobes, but it is certain that this latter takes place independently of cranial circumscription, especially in many fishes where the cranial cavity far exceeds the brain mass; and it would be interesting to ascertain whether this interspace exists in any of those fishes which, like *Elacate*, present some cerebral fissuration. At present the matter must be regarded as undecided; and the way to elucidate our own lack of information is to ask ourselves whether, in total absence of cranial walls, any cerebral convolution would be developed in the higher *Mammalia*.

Fissural Homologies.—In order to describe the variations of fissures in different brains, they must first be identified. Although Owen has (Comp. Anat. of Vertebrates, vol. iii, pp. 114 to 143) undertaken to homologize the fissures of the higher mammalia (*Gyrencephala*) throughout, and has rarely admitted the liability of error (as on p. 117), yet the very completeness of his determinations throws doubt upon them in view of the lack of reference to individual peculiarities, and the renunciation of development as a guide to homology; and it will be safer to keep in view the conclusion of Gratiolet. (Mem. sur les plis cerebraux de l'homme, p. 10.)

"It is sufficient to compare the brain of an ape with that of a carnivore or ruminant in order to show that in the different mammalian orders, the cerebral folds present very different arrangements.

These differences are such that it would be imprudent to establish parallel divisions and to search for homologies. In fact that search has no certain basis, and we do not hope to accomplish it in a moment."

Criteria of homology.—Having no true structural features, they present, as tests of homology: 1. Position in relation to internal structure (as the *rhinal* and *sylvian*). 2. Position in relation to other fissures so determined. In connection with this latter test, we must ascertain whether anything like *transposition* is possible; this question will be raised in respect to special fissures. Their connections, branches, length, and general direction are probably of less value. Great aid is always to be had by comparison with simpler brains of allied species, or with the brains of young of the same species. The extent of variation in length, direction and connections, which may exist without invalidating their homology, is most readily seen by comparing the corresponding fissures upon the two halves of one brain (plate 3, figs. 12, 13); it appears that a long fissure may be represented by several short and disconnected ones; that branches may or may not exist at either end (these branches are almost invariably dichotomous); that two fissures wholly separate in the fœtus, and in other species, may unite either directly or by a branch. Good examples of this are the *lateral* and *coronal* fissures, which are perfectly distinct in the fœtus, in some adults, and on one side only of others, but which show a tendency to unite; a marked constancy in the location and direction of a branch may, as in this case, indicate the point of union. Finally, with respect to several fissures, we must either deny a homology which would be otherwise unquestioned, or admit that in one species or on one side, its manner of formation may greatly differ. This will be exemplified in connection with the special fissures in this and the following paper; for example the *presylvian*, and the *ectosylvian*. While insisting, however, upon the provisional nature of many of the names which authors have given to the cerebral fissures of mammals, it is necessary to adopt some nomenclature in order to be understood, and in the present paper the names given by Owen will be employed with some modifications.

SPECIAL FISSURES. THE SYLVIAN.—This is the most constant of all fissures; there is no question respecting its existence or its name in all brains which are fissured at all.*

Its length, direction, branches and connections vary consider-

*On this account I have not hesitated to mark this fissure upon all the figures, s; but since there is some doubt respecting the name or the nature of all other fissures, the letters designating them are placed outside of the figure, in order to allow revision; most of the figures are shown white on a dark ground; this will allow future alteration in the relative width of fissures in order to indicate their depth or relative constancy.

ably, but, as a rule, in the adult it forms a nearly straight fissure directed dorsad and backward, never reaching the dorsal margin of the hemisphere, and rarely if ever inclining forward, though generally nearly vertical in *Herbivora*. Its manner of formation is very peculiar, and may be readily traced in new born or fœtal kittens and puppies; in these and also in the fœtal wolf (fig. 6), there appears, where in the adult the sylvian is to join the *rhinal*, a rounded elevation (which is probably homologous with the *Insula* or Island of Reil, of anthropotomy) bounded above and behind by a shallow trench; in front this island is apparently continuous with a narrow area of cerebral substance which still more anteriorly broadens into that part which lies just behind the olfactory lobe; the primitive *sylvian* fissure is therefore an ∞-shaped depressed line whose posterior end joins the rhinal, and whose anterior end is turned upward; by the gradual projection of the cerebral mass above this line, it overhangs the depressed tract, so that the ventral part of the curve reaches the *rhinal* fissure and coincides with it for a certain distance; this portion I have ventured to call the *basisylvian* (Bs); by the growth of the mass before and behind the semicircular area now left, and the final approximation of the walls, the Insula is at length wholly concealed, and the semicircular trench becomes a single fissure; strictly speaking therefore, the sylvian is an arched fissure like those which surround it (*ectosylvian*, *supersylvian* and *lateral*).*

PRESYLVIAN (Ps.).—The anterior and ascending (dorsad) extremity of the *primitive sylvian* seems to correspond with the "ascending

*From a translation (Cerebral Convolutions of Man) which has just come into my hands, I find that Ecker of Freiburg, four years ago, observed the formation of the *sylvian* fissure, and that some of his conclusions upon this and other points are nearly like my own. I am sure that Ecker will be only glad that another has reached similar results from different materials, for he employed human brains exclusively, while I have purposely discarded them for the simpler brains of *Carnivora*. Certainly he and all other honorable scientific men would accept the collections and drawings made by me as evidence of my entire independence in the work; but for the satisfaction of others, including the writer of an editorial in "The New York Evening Post" for Aug. 30, which directly charges me with unacknowledged borrowing from Ecker, I am compelled to state that to-day, Sept. 8, 1873, for the first time, have I learned the contents of Ecker's work.

Moreover, while not questioning the correctness of Ecker's statement that in man "the whole hemisphere curves itself in an arch, concave below, around the place of entrance of the cerebral peduncle" (p. 15), it is proper to say that the brains of kittens and puppies examined by me do not confirm it; nor is it easy to see how so long a fissure as that of the bear could be formed in that way; it is evident that for the elucidation of this and many other points, we need a very extended series of observations upon the developing brain of many animals.

branch" (Ecker, fig. 1, S″) in its manner of formation, and in its relation to the *sylvian;* but the intervening space in all brains I have examined is so much larger than the "operculum" of anthropotomy that I hesitate to affirm it before observing its formation in many intermediate species. Moreover, in a lion (fig. 18), there is a small fissure between the *sylvian* and what I take to be the *presylvian*, which in some respects more nearly resembles the "ascending branch" in man; while in a bear (fig. 10) and raccoon (fig. 11) there is a similar one in front of the *presylvian*, which may be only a continuation of the slight upward curve at this point which the *rhinal* presents in many dogs. I would suggest the name *presylvian*, at least for the fissure already described in *Carnivora.* It is evidently the same which Flower refers to as *superorbital* (Anat. of *Proteles;* Proc. Zool. Soc., 1869, p. 479), but there seem good reasons for regarding it as ideally, at least, a dismemberment of the *sylvian.* I say *ideally*, for although generally so in *fact*, yet occasionally there is no connection whatever, and that which would in respect to position be called *presylvian* is an isolated fissure. This is the case on both sides of a raccoon (fig. 11),* and on the left of an impure tan terrier dog; of the right of this brain I have no drawing, but think the union is as usual. This is certainly a point which should be clearly understood before we can be sure of the value of our determination; at present I am not prepared to explain it. It will be noted also that in most dogs and in the lion, the *presylvian* is not only very long, but apparently double, as if a special and independent fissure had become connected with its dorsal end; whether this is the case can probably be decided by sections, for there is reason to think that an independent fissure is always deepest at its middle where it may generally be supposed to commence; and if the fissure in question is shallower at the point of suspected junction we may fairly conclude that it is really a compound fissure.

FRONTAL† (F.). This fissure is very characteristic of *Carnivora*, being absent, so far as I know, only in *Paradoxurus* figured by Gervais. (Nouv. Arch. du Museum, tome vi, pl. 9, fig. 2.)

*But in another specimen the connection seems to exist as usual.

†I have adopted Owen's name as applied originally to the brain of *cat* and *cheetah*; but am not sure that it is homologous with that so called by him in the human brain. Flower has called it *crucial*. P. Z. S., p. 479.

The *frontal* appears from without as a cleft in the mesial margin; in kittens it begins as a mere shallow depression which rapidly deepens and narrows; it is nearly as much a mesial as an outer fissure, and in some cases joins one of the mesial fissures so as to appear a continuation of it; as seen from above the frontal extends outward and sometimes forward (as in fox). As a whole I have seen it take a backward course, only in a black bear, both sides, and a skye terrier, right side, although when curved, its outer end may turn slightly backward. It rarely branches, or if so but very slightly as on the right of a St. Bernard (524); in some cases, as in right of bull terrier (514); an apparent bifurcation is merely the union with it of a small secondary fissure. But even such junction is very rare; on right of bear (502, fig. 10), it joins another at right angles, but on left a considerable space intervenes.

SUPERSYLVIAN (Ss.). Next in independence, in constancy, and in order of formation seems to come that semicircular fissure which Owen calls *supersylvian;* perhaps it should precede the frontal in the above respects, but like so many other points, my present material does not enable me to determine this. I am quite certain, however, that Owen's table (C. A. V., iii, p. 136) does not in all respects (as its author admits) represent the relative rank of all the cerebral fissures. It generally divides the surface of the hemisphere into two subequal portions; its usual relation to the other fissures is seen in the fox (fig. 3) and the fœtal wolf (fig. 6). In this, it forms a nearly regular curve with no branches or connections; and whichever we may conclude to be its representative, in the young terrier (fig. 7) it would appear to begin as a longitudinal groove about midway of its final extent and nearly over the *sylvian.* This is also the case in cats; but in most brains its hinder end either branches or joins some small fissure, while, as a rule, its anterior end bifurcates, the longer arm reaching forward and ventral often with a slight dorsal turn at the extremity, while the shorter points obliquely forward and dorsal and often enters the lateral fissure just outside (as in hyæna, fig. 9). This little branch so closely resembles the one which is given off at the junction of the lateral and coronal in nearly all cases as to suggest that it is, like it, due to a union of two independent fissures; but of this there is no evidence. The fact that a similar branch sometimes leaves the *ectosylvian*, as in fox (figs. 3 and 4), suggests a like constitution for this latter fissure, or else a serial arrangement of cerebral foldings which is not as yet accounted for upon any theory of correlation between mind and brain.

In a lion (fig. 18) the Ss is irregular, with branches and junctions with other fissures. In a bear (fig. 10) and raccoon (fig. 11) we have a peculiar arrangement, the explanation of which I forbear to suggest until I see fœtal brains of these species. The weasel presents only two fissures where most *Carnivora* have three, and it is not easy to say which they are; a similar doubt is admitted by Owen (C. A. V., iii, p. 117) in comparing the brain of *Coati* (*Nasua*) with that of the stoat; and I ask no better evidence of the fact that our knowledge of the zoological value of fissures is as yet incomplete than the comparison between my figure of the weasel's brain (fig. 8) and Owen's figure of the stoat's; for the animals are similar species of closely allied genera, if not, indeed, members of the same genus (Allen, Bull. Mus. Comp. Zool., No. 8, p. 167), or varieties of the same species (Gray, Proc. Zool. Soc., 1865); yet my figure shows two fissures outside of the *sylvian*, while Owen's has but one which he calls *supersylvian*.

Lateral (L.). This is usually a curved furrow which divides the space between the *mesial* border and the *supersylvian* into two nearly equal parts.* The name was given by Owen, probably in reference to its approximate parallelism with the mesial border, which is often quite striking, as in the lion and hyæna; but its anterior extremity is inclined to connect with another fissure, the *coronal*, so constantly and so smoothly that but for occasional exceptions and observations of fœtal brains, one would incline to regard the whole as a single fissure with a branch, mesiad, resembling that of the *supersylvian;* but a careful comparison indicates that the *lateral* generally bifurcates anteriorly, and that the ventral arm is joined by the *coronal;* occasionally they miss connection, as on left side of terrier (fig. 12), shepherd (512), and of another small dog (540), on right of pointer-shepherd (fig. 14), and on both sides of skye terrier (503) and young tan terrier (534), on

*This division of the cerebral surface into subequal areas by the fissures will be mentioned in the next paper; of course, as the hemisphere is convex, no figure can represent the true relative distances of the fissures unless the surface is projected upon a plane (as is done with a fox's brain, fig. 5); it would appear, however, upon a series of transverse sections, which I hope to show upon another occasion.

left side of lion, and in cats generally; the weasel has no *coronal;* the bear and raccoon are peculiar in this as in other respects. In the young terrier (fig. 7) the *lateral* is very short and the union has not taken place. The *Coronal* (C) may be passed over with what has been said in connection with the lateral. But there are two secondary fissures which are associated with the hinder end of the *lateral;* one of them, which generally occurs in cats, has been called *medilateral* by Owen; it lies *mesiad* of and usually behind the *lateral* and often joins it, but seems to be an independent fissure. When there is any fissure mesiad of the *lateral* in dogs, it lies farther forward, and is generally interrupted, so that I am not certain of the homology; but in some cats (fig. 15) the true *medilateral* seems to coexist with an anterior fissure mesiad of the *lateral;* while in some dogs, greyhound (fig. 16), the *lateral* is prolonged backward, *as if* by a *medilateral*, while a separate fissure, apparently a true Ml, lies between it and the mesial border, and another, El, lies outside between it and the *supersylvian.* This last, which has not so far as I know received a name, may be called the *ectolateral.* Flower evidently alludes to its constancy in *Canidæ* (P. Z. S., p. 482), as occasioning the bifurcation of the posterior limb of the third gyrus (the value of his generalization will be discussed farther on).

Ectosylvian (Es.). This fissure is in some respects the most peculiar of all, for it presents differences not only of adult condition, but also of manner of formation, which lead us to doubt the value of this character. Its simplest, and what may be regarded as its normal, aspect is presented in the young terrier and fœtal wolf, and in the adult fox, where it forms a curved line of greater or less extent between the *sylvian* and the *supersylvian* (it is probably wanting in the weasel, fig. 8); this regular form occurs also in some dogs, as a setter (10) (left side), and St. Bernard (524) (right), where, however, there are two or more small offshoots from the convexity, like the single and apparently normal anterior one of the fox; but while the above instances would suggest that the ectosylvian is a simple arched fissure commencing at a point just above the tip of the sylvian, and increasing at both ends, many others would incline us to describe it as composed of three independent pieces, one in front, and one behind the sylvian, and the third connecting those above it; as, for example, in the terrier (fig. 25).

And that this is a not impossible view of its formation is shown by the fact that in several dogs, as right terrier (511) (fig. 13), and left greyhound (fig. 16) and St. Bernard, this top piece is apparently wanting altogether, leaving the front and hind posts of the door unconnected. This is apparently the normal condition of things in all *Felidæ* (fig. 17), although the ends may branch, and, even as in lion, join other fissures. In many dogs, as the Pomeranian (fig. 20), the posterior upright may be in great part wanting, or abbreviated and joined with the *sylvian;* finally, in *Hyæna* (fig. 9), the anterior upright *seems* to be transferred *behind* the *sylvian;* but this involves a very grave general question of homology which there is no means of solving at present.

It will be understood that the foregoing are by no means offered as full accounts of the outer fissures, even with respect to my present materials; but rather as hints for monographic work upon them when a larger number of specimens or accurate drawings shall be available. Let me suggest in this connection, however, that to be useful, the *original drawings should be made by the anatomist*, and that the transfers should be made under his eye; an abbreviation or extension of a fissure, which would appear trifling to the most conscientious artist, might involve a contradiction of important generalizations respecting its connections.

But before any final work can be done in respect to fissures, we need a *complete account* of the brain of some one mammal, giving its appearance from all sides, sections and dissections of all parts, and demonstrations of the relations which may exist between the fissural pattern and the internal structure; then a full series of figures representing all the stages of development, both of the brain as a whole and of its parts; on some accounts the fox would be the most useful species, but as it is not to be had in large numbers, and as dogs are ineligible as a standard, from the breed differences as well as from the usual complexity of the fissural pattern, we shall probably find the cat most available for this purpose; such a work would form a fitting continuation of Straus-Durckheim's magnificent monograph of the Osteology and Myology of that animal.*

TAXONOMIC VALUE OF THE FISSURAL PATTERN. Upon this point Gratiolet speaks as follows (*op. cit.* p. iii) :—

*It is one of the tasks which I wish to accomplish, but trust this will not deter others from undertaking it.

"In like manner there is a particular type of cerebral folding in the makis, the bears, the cats, the dogs, etc.; in short, in all the families of mammalia (d'animaux). Each of these has its own character, its norm, and in each of these groups the species can be easily combined according to the sole consideration of cerebral folds."

Gervais* concludes that we may recognize order, family, genus and even species by the brain (Nouvelles Archives du Museum, 7, vi, p. 152).

Flower says (*op. cit.* p. 480): "For working out all the modifications of the brain convolutions of the *Carnivora*, a larger number of specimens would be required than are at present accessible; but the series in the museum of the College of Surgeons is sufficiently extensive to show that they will furnish important indications of affinity, and that these indications correspond remarkably with the evidence afforded by the cranium, digestive and reproductive organs."

While admitting the *probability* that such a family norm of fissuration does exist and may hereafter be designated, yet the careful study of an amount of material greater in some respects, at least, than previous writers seem to have had, only makes me urge the importance of Gratiolet's remark, that "the value of any conclusions respecting ideal unities has a necessary condition, that of resting upon a sufficient number of exact observations" (*op. cit.*, p. iii). The need of this may be seen by an examination of Flower's generalization, respecting the very groups which we can best illustrate (*op. cit.* p. 482).

"The dogs (*Cynoidea* = *Canidæ*) are very uniform in their cerebral characters having always four distinct and regular gyri surrounding the fissure of Sylvius, which is short and approaching a vertical direction. The first and second arched gyri have the anterior and posterior limbs equal, the third has the posterior limb broad and bifurcated."†

"All the other *Carnivora* have only three arched gyri on the outer surface, the first or lower one of the dogs being either wanting or concealed beneath the second within the fissure of sylvians. In the hyæna its hinder limb is partly exposed."

"In the *Arctoidæ* (=*Ursidæ*, *Procyonidæ*, *Mustelidæ*, *Ailuridæ*,

*But although this author figures the brains of eighteen species of Carnivora (and casts of the cranial cavities of these and other species) he seems to ignore the existence of individual differences, and gives but a single brain for each species and none whatever from dogs (excepting casts).

†By what I have called the *ectosylvian* fissure.

Lutra and *Enhydra*), the fissure of Sylvius is rather long and slopes backwards; the inferior gyrus has the limbs long, corresponding with the length of the sylvian fissure; the anterior rather narrower than the posterior (especially with the true bears); the middle gyrus is moderate and equal-limbed; the upper one large, very broad in front and distinctly marked off from the second posteriorly, as far as near the lower border of the temporal lobe; except in the smaller members of the genus *Mustela* where the sulcus separating the superior from the middle gyrus is less produced posteriorly than in others of the group. In *Galictis vittata*, however, the brain is quite a miniature of that of a bear; but the middle convolution is united with the upper one at its superior anterior angle."

"In the *Æluroidea* (including all other Carnivora excepting the *Pinnepedia*), the sylvian fissure is moderate and nearer to the vertical than in the last group. The gyrus which immediately surrounds it is wide, especially the posterior limb which is generally twice the width of the anterior and is divided by a vertical fissure,* well marked in the cats and hyænas. In the cats the anterior limb is also partially divided. In the civet both limbs are simple, the second gyrus is moderate and simple. The superior gyrus is wide in front but small posteriorly, the sulcus which separates it from the second not extending quite to the hinder apex of the hemisphere (the suricate agrees with the hyænas rather than with the civets in the general character of its brain convolutions)."

Of the *Arctoïdea*, Prof. Flower may have had more material than I, but in the absence of exact enumeration, his characterization of the fissural pattern seems to me insufficient at least; if by dogs, Prof. Flower includes only the feral *Canidæ*, his generalization may be not far from correct; although the backward slant of the *sylvian*, in both my own and Gervais' drawings, is generally greater than in hyæna and weasel, and equal to that of cat and lion. But if the domestic dogs are included the definition would not apply to many of them; for the bifurcation of the third gyrus is often so complete as to constitute two equal gyri, as on left of terrier (fig. 12), and the outer or fourth gyrus may be likewise bifurcated, as in left of greyhound (fig. 16), while the first and second gyri are, as a rule, rendered irregular by the peculiarities of the ectosylvian; moreover, the generalization respecting all other

* Which I believe to be the hinder upright of the *ectosylvian*.

Carnivora involves a denial of the homology of the complete *ectosylvian* of the fox with the incomplete one of the cat, yet this last is very nearly like those on the left of the terrier (fig. 12) and greyhound (fig. 16).*

Other discrepancies might be pointed out, if it were possible to present, in this paper, figures of all the brains which I have prepared; but so long as Prof. Flower makes no reference to the differences of individuals of the same species, to variations of age and sex, or to differences between the right and left sides of the same brain, I shall be obliged to doubt the value of the generalizations.

Lateral Variation. I wish it had been possible to offer here drawings of both sides of all the brains of the feral, as well as domestic *Carnivora*. I do not recall a case in which this lateral variation has amounted to the total absence of a main fissure upon one side; it consists rather in a difference of length, depth, branches and connection, or of nearness to other fissures; the minor fissures, however, present very great lateral variations as to presence and location. Since most of the examples given are from domesticated dogs, I do not wish to lay too much stress upon the fact of lateral variation, but in no work have I seen both sides of an animal's brain figured or described; and since no two brains of different species can be so nearly related as the two halves of the same brain, it is evident that a careful study of lateral variation will furnish a test of the value of the differences observed among brains (see plate 3).

Lateral Compensation. Lateral variation is often *compensatory*. For instance, a long fissure of one side may be represented by several short ones upon the other, the aggregate length being equal to the single one; a straight fissure may represent a curved one; or a single one may have as counterpart a shorter one with a branch; in one case, the total length of a bifurcated sylvian fissure is just that of the longer but undivided fissure of the opposite side.

*The foregoing certainly raises the question whether we can rightly look for taxonomic assistance among the organs of domesticated animals: but meantime it seems proper to include our canine varieties in any generalization respecting the group of *Cynoidea*.

The functional significance of this will be alluded to in the next paper.

Conclusion. The foregoing is far from a satisfactory view of the subject; but it is all I can offer at present. My chief object has been to point out the defects of our methods of preparing and drawing brains, and the insufficiency of material for making any generalization respecting that mammalian order whose brains are most readily obtained and whose fissural pattern is comparatively simple. With a single specimen or figure of the brain of *Felis*, *Canis*, *Hyæna*, *Ursus*, *Mustela*, one might make generalizations as to specific, generic and family fissural patterns which would be quite as true to nature as many which are annually published upon this or other departments of Comparative Anatomy, but they might be controverted by other specimens or even by the other halves of the same. The greater complexity, both from secondary fissures and from contortions of the primary fissures, which prevails with the brains of most *Herbivora*, is an *a fortiori* argument against making the attempt to determine their fissural patterns before the *Carnivora* are disposed of. After a pretty careful study of the specimens and works at my command, I feel justified in asserting that we cannot as yet characterize the fissural pattern of any mammalian order, family, genus or even species without the risk that the next specimen will invalidate our conclusion; that our studies in this direction should be based upon the careful comparison of accurate drawings of a much larger number of specimens than now exist in any museum; that nearly allied forms of *Carnivora* should be compared; and that the most satisfactory results are obtainable from large series of fœtal and young brains of the same species, and, if possible, family and sex, in order to eliminate minor differences.

Addendum on the Lion's Brain. The kindness of Mr. Lee Powell* has just enabled me to prepare the brain of a young African lion, seven and one-half months old; the left hemisphere is here figured (fig. 19) for comparison with the Asiatic. The most striking difference is in the great development of the temporal lobe (the postsylvian region), which not only projects laterally more than in the other, but also *forward* over the region

* Of Robinson's Circus and Menagerie, Utica, N. Y.

just in front, so as partly to cover it and make the ventral portion of the *sylvian* coincide with the ventral branch of the *ectosylvian*, (Es); the frontal region is less prominent, and the outline of the cerebellum is quite different. In the Asiatic lion the left *coronal* is wholly independent; likewise the right *coronal* of the African; but the right of the former joins the *lateral*, which is the usual arrangement, while the left of the latter joins the *supersylvian* in a similar fashion. Other differences might be pointed out both between the two brains and the two halves of each; but it seems to me that these alone are enough to make us hesitate from basing a *diagram* of the fissural pattern of this species upon any such number of specimens as are likely to be found in any museum; while the same peculiarities present almost insuperable obstacles to a recognition of particular folds as organs of special mental faculties separated by certain fissures.

[The figures illustrating this paper are given in the plates, between pages 248 and 249, and their explanation will be found on page 249.]

Cerebral Variation in Domestic Dogs, and its Bearing upon Scientific Phrenology. By Burt G. Wilder, of Ithaca, N. Y.

The following observations are based upon the careful study of thirty-two dogs' brains, representing fifteen to twenty breeds. There were four of the same family, a mother and three children of different ages; two others nearly related to them, and two pair of brothers of different ages; the others are not known to be related; most of them are supposed to be of pure breeds.*

*The figures referred to in this paper are included with those of the preceding paper in the plates placed between pages 248 and 249.

LIST OF DOGS' BRAINS PREPARED AND DRAWN BY ME, AND FORMING THE MATERIAL UPON WHICH THIS PAPER IS BASED.

M. C. Z.* No.	Breed.	Age.	Sex	Weight of Body, in grams.‡	Weight of Brain.	Ratio, in thousandths.	Fig.
1	Pomeranian or Spitz.	adult.	♀	8,837.	,068	.007	20
3	" } children of No. 1, by the same father, but of 2 separate litters.	5 weeks.	♀	1,316.	,047	.035	21
2	"	4½ "	♀	1,006.	,041	.040	22
4	"	54 hrs.	♂	,132.	,008	.060	23
215	" } later children of mother of father above mentioned.	3 days.	♀	,213.	,010	.047	24
216	"	3 days.	♀	,247.	,011	.044	25
	Eng. rat terrier (small blk. and tan).	at birth.	♀	,092.	,005	.054	
522	Eng. rat terrier brother of above.	24 hours.	♂	,081.	,008	.099	
	Spaniel ¾ pure.	at birth.	♀	,221	,007	.030	
511	Eng. blk. and tan terrier (small).	6 mos.	♀	1,320.	,038	.028	12,13
512	Shepherd.	young.	♂	1,952.	,055	.028	
540	Shep. cur (pt. terrier?)	6 weeks.	♀	2,228.	,058	.021	
541	Mexican (Chihuahua).	17 years 8 mos.	♂	2,436.	,050	.020	
6	Eng. terrier } brothers.	9 mos.	♂	5,300.	,074	.014	
7	"	3¼ yrs.	♂	5,300.	,069	.013	25
526	Italian greyhound.	1 yr.	♂	6,074.	,067	.011	
8	Ital. greyh'nd impure.	adult.	♂	4,367.	,065	.010	
520	Spaniel (large impure).	adult.	♂	6,158.	,062	.010	
536	Chinese (hairless).	9 mos.	♂	7,026.	,074	.010	1
503	Skye terrier.	15 yrs.	♂	7,800.	,072	.009	
578	Hound.	20 yrs.	♂	22,450.	,108	.005	
9	Setter (large).	12 yrs.	♂	25,400.	,106	.004	
	Newfoundland.	adult.	♂	38,345.	,120	.003	26
13	Bull and cur.	12 yrs.	♂†	40,570.	,125	.003	
	St. Bernard.	old.	♀	40,820.	,098	.002	
25	With seven others the record of which is more or less imperfect.						

No. 7 was not weighed; he was slighter in form than No. 6, but the weights are assumed to be equal; the "fresh weight" of the brain is computed by forming a proportion with another brain

* This is the number on the Catalogue of preparations of Domesticated Animals in the Museum Comp. Zool.

† Castrated at about six years old.

‡ For uniformity, a *full stop* is placed after the number of grams (the unit of weight), and a *comma* after the number of kilograms (1000 grams).

of nearly equal weight when hardened, but the fresh weight of which was also known: as to the weight being greater than that of the older brother's brain, I can only adduce the greater mental and physical activity which it displayed.

The brains of dogs are by no means common in museums, and figures of them are even more rare, partly, perhaps because the very commonness of the species induces delay in its examination,* but partly, I am inclined to think, from a notion that since they are all called dogs, there can be no great anatomical differences between them. Yet aside from any question of their origin from different specific forms of feral *Canidæ*, the fact is patent that our various breeds of dogs differ among themselves in respect to size, color, form and habit far more than would be required for the discrimination of species among wild animals; and there have not been, so far as I am aware, any investigations to show whether, or not, these external distinctions coexist with structural peculiarities.

It had long been my wish to undertake such an inquiry; and the liberality of Prof. Agassiz, in authorizing me to make for the Museum of Comp. Zoology a collection to illustrate the neurology and embryology of domesticated animals, has afforded me the means of commencing the investigation.

The table of absolute weights of brain and its ratio in thousandths to the whole body is mainly confirmatory of the general rule that young mammals have proportionally larger brains, and that the smaller species and varieties in like manner excel the larger; but the difference between, for instance, a little tan terrier and a Newfoundland is something prodigious, as seen by the following selected table, where the large dogs are represented by the Newfoundland, the medium sized by the English terrier (common size) and the small and young dogs by the small terrier and youngest Pomeranian.

No.	Variety.	Age.	Body.	Brain.	Ratio.
4	Pomeranian.	54 hrs.	,132.	,008.	.060
8	Eng. terrier (small).	6 mos.	1,320.	,038.	.028
7	" " (large).	3½ yrs.	5,300.	,069.	.013
	Newfoundland.	adult.	38,345.	,120.	.003

*As the house fly and mosquito are seldom among the first captures of the entomologist.

Generalizations like the above, and others which might be made respecting the ratios at different ages, in the two sexes and in various breeds, are evidently provisional until we have a much larger mass of material.

I would add that measurements were taken of the intestines; the capacity of the stomach and coecum was recorded and all viscera were weighed, so that I shall at some future day be able to present some statistics respecting them, and also respecting the degree of variation in the form of the stomach and coecum, of which many specimens are preserved, inflated, either at Ithaca or in Cambridge. This is the case also with all the other mammals here mentioned.

TABLE SHOWING THE RATIO OF BRAIN AND BODY WEIGHTS OF A FEW MAMMALS, CHIEFLY CARNIVORA.

M.C.Z.	Scientific name.	Common name.	Age.	Sex.	Weight of body.	Brain	Ratio.	Jaw-flexors.
577	Macacus?	White faced.	5 yrs.	♂	2,939.	,082.5	.028	
	Vulpes fulvus.	Red fox.	adult.	♀	2,918.	.047.	.016	.073
530	Canis lupus.	Gray wolf.	4 days *a. p.*		,460.	,009.	.019	
	Canis familiaris.	See special table.						
	Felis catus dom.	See special table.	average of 6 adults.		2,847.	,027.	.009	
552	Felis leo.	African lion.	7½ mos.	♂	11,230.	,162.	.014	.117
12	Hyæna vulgaris.	Striped hyæna.	old.	♀	33,770.	,110.	.003	.800
502	Ursus Americanus.	Black bear.	1 yr.	♀		,240.		.550
577	Procyon lotor.	Raccoon.	adult.	♂	5,540.	,044.	.008	.010
528	Putorius Noveboracensis.	Weasel.	nearly grown.		,100.	,005.	.050	
188	Equus caballus.	Mare.	14 yrs.	♀		,684.		
379	" "	"	adult.	♀		,597.		
175	" "	Horse.	adult.	♂		,580.		
347	" "	Colt.	at term.	♂		,361.		
354	" "	"	?		15,938.	,190.	.012	
325	Bos taurus.	Durham bull.	2 yrs.	♂	5[illegible]0,000.	,337.	.0006	
537	Camelus bactrianus.	Camel.	?	♀	299,813.	,615.	.0025	1.247

In comparing the weight of the brain with that of the flexors of the lower jaw (*temporals* and *masseters*) we find, for instance, that the jaw muscles are about eight times heavier in a hyæna, four times in a Newfoundland, twice in a bear, a fox, and camel, but the same weight in a tan terrier, while in the young lion (552) they are only about two-thirds the weight of the brain, although this ratio must alter greatly as the animal grows older.

TABLE OF TWENTY-THREE DOMESTIC CATS.

M.C.Z.	Variety.	Age.	Sex.	Body.	Brain.	Ratio.
220	Common ? } same litter.	17 days.	♂	,180.	,013.	.072
219	" } same litter.	"	♂	,262.	,013.	.049
218	" } same litter.	"	♀	,250.	,013.	.052
222	"	5 days.	?	,128.	,018.	.063
40	"	3 days.	?	,080.	,004.	.050
38	"	at birth.	♀	,110.	,005.5	.050
39	" (sister of 37).	36 hrs.	♀	,075.	,003.5	.047
37	"	12 hrs.	♂	,092.	,003.5	.038
542	Maltese.	?	♂	,560.	,022.	.037
48	"	23 days.	♂	,359.	,014.	.039
25	" (in part).	?	♀	,648.	,021.5	.033
24	" " "	2 mos.	♀	,800.	,025.	.031
34	Common.	3 days.	♀	,099.	.003.	.030
510	Maltese (in part).	?	♀	,963.	.023.	.024
26	"	?	♀	1,770.	,026.	.015
32	Common.	adult.	♀	1,882.	,025.	.013
	"	"	♂	2,591.	,031.	.012
20	" (striped gray).	young.	♀	1,912.	,023.	.012
30	Common.	?	♀	2,276.	,027.	.012
23	"	adult.	♀	2,370.	,028.	.012
28	"	"	♀	2,978.	,027.	.009
22	Maltese (in part).	"	♂	4,550.	.031.	-007
21	" " "	"	♂	2,712.	,025.	.007

The following inferences may be drawn, provisionally, from the foregoing table.

1. The ratio of brain to body, in the adult cat, is about the same as in the adult dogs of the medium sized breeds: namely, .007 to .015.

2. In kittens of the same litter (as 218, 219, 220 and 37, 39) the brain weights are more uniform than the body weights, and the latter causes a variation in the ratio.

3. Although the increase of the *body weight* is much more rapid than that of brain weight, when the whole period of growth is considered, yet a comparison of 38, 39, 37, 34 with 218, 219, 220, 222, 48, shows that the brain must grow very rapidly during the first two or three weeks after birth concomitantly with the increase in bodily powers and the use of the senses.

A comparison of 2 and 4, among dogs, looks the same way; and in both cats and dogs, it will be remembered that the formation of fissures proceeds very rapidly during the earlier days. With pigs, calves and colts, on the other hand, I have found the fissures already deep and numerous long before birth, and it will be interesting to contrast the relative increase of brain and body weights in the *Carnivora* and *Primates* which are born helpless, and the *Herbivora*, which are in fuller possession of their faculties at birth.

General Form.—Some dogs' brains are high and rounded, while others are low, long and narrow in front; of the latter type are those of setters, Newfoundlands (Fig. 26), St. Bernards, shepherds and bull dogs; in all of these the olfactory lobes are visible for about half their extent when the brain is seen from above but they are wholly concealed by the hemispheres in the Pomeranians (Fig. 20), greyhound (Fig. 16) and terriers (black and tan, Fig 12), the Chinese and Chihauhau dogs; and between the two groups come the bull terrier and skye terrier.

In the fox and wolf the brain is narrow and low in front, but in the lion it is rather high; while in the domestic cat, though low, the frontal region is very broad; evidently, however, it is not easy to discriminate between the effect of large size of a certain region and the relatively small size of an adjoining one, and it must be remembered that in all very young dogs' brains the olfactory lobes are hidden, but this is probably from their own undeveloped condition.

The greater prolongation of the olfactory lobes and of the adjoining region of the cerebrum, in front of the *presylvian*, which generally prevails in the larger dogs at least, as compared with the *Felidæ*, might be held to indicate their superior power of scent; but this proves nothing respecting any *mental faculty*.

M.C.Z.	Animals.	Fig.	Length of Hemisphere in millimeters.*	In front of frontal.	Ratio.
13	Bull and Cur.		.069,	.023,	.333
7	Tan terrier.	25	.053,	.010,	.188
14	Pointer and shepherd.	14	.045,	.013,	.288
	Cat.	17	.032,	.003,	.094
510	Lion.	18	.071,	.013,	.183

The above table is in no way intended as an index of the zoological or psychological relations of the several animals, but as a single proof of the impossibility of basing generalizations respecting groups upon one or even several individuals; for in respect to an element of brain form which might naturally be noted in any attempt at characterization, there is nearly as much difference between two dog varieties as between two Feline species, or between the cat and the terrier.

Fissural Complexity.—There must be, of course, a limit to the depth of fissures (or to the elevation of folds), although we have, as yet, no means of ascertaining the nature of the limitation, nor whether it is uniform in all brains; but supposing it to be equal in two given cases, it is evident that a larger number, or length, whether of branches or secondary fissures, indicates a correspondingly larger amount of gray matter; and this, supposing its *quality* to be equal in the two cases, indicates a greater amount of brain power.

1. Now the cerebral mass is capable of expending nerve force in three directions, which are ideally distinct, at least in their purpose, but practically linked together in most cases.

1. Physical, } for the individual.
2. Mental, }
3. Sexual, for the species.

At present we have no way of ascertaining from the brain alone, whether its peculiarities relate to greater mental, physical, or sexual power.

We would naturally account for the more numerous fissures of dogs, as compared with the feral *Canidæ*, upon the ground of

*A *full stop* is placed after the place for the number of *meters* (the unit of measure), and a *comma* after the millimeters (thousandths of a meter.)

their higher mental capacity; and upon this ground must be explained the somewhat remarkable fact that the brain of an adult Pomeranian female (Fig. 20) has fewer fissures than that of her five weeks old pup (Fig. 21); for the father was a trained dog, while the mother was comparatively unintelligent.

But the wolf, according to Gervais' figure, has more secondary fissures than the fox, and this must be accounted for by its greater *physical* power.

Perhaps this is also the explanation of the great fissural complexity of the young lion, as compared with the adult cats or even most dogs; but Professor Agassiz has suggested to me that the greater power indicated by the condition of the lion's cerebrum may be connected with its prodigious *virility*, the complete sexual act having been performed nine times in an hour, under his observation, and the same rate having been maintained during at least two successive nights.

In a young lion's brain (Fig. 19) the depth of the *supersylvian* fissure is at least one-half the thickness of the hemisphere at that point and in its plane; while in an adult cat's brain the depth was only one-fourth, and in a dog's about one-third; all the other fissures were very deep in the lion, and the layer of gray matter very thick.

I hope to make a careful measurement of several dog's brains, according to the method adopted by Wagner, with such suggestive results.

2. There are *individual variations* among the adults which do not affect the presence or relative position of main fissures, but their length, direction, branches, connections and continuity, and, by inference, the manner of their formation; these variations enable us to recognize any brain and may in some cases approximate them to other carnivorous families.*

3. The two sides of the same brain present just such variations as those above described between different individuals.

The few instances cited show to what extent this variation may exist; so great is it, indeed, that I do not think it possible to "mate" two hemispheres by their fissural pattern alone, without taking into account the similarity of size, or general form.

* The resemblance of the *ectosylvian* fissure of certain dogs to that of the cats is referred to in the preceding paper.

The number of specimens is not yet large enough to justify any inference respecting the sexual peculiarities of brains.

4. There are resemblances between brains of the same breed, which lead us to suspect the existence of a uniform modification of the general pattern for different breeds.

This is noticeable in the Pomeranian series; but in the first place some other brains show the same tendency of the *ectosylvian* to join the *sylvian*, and in the second place the near relationship of all the younger dogs to the single adult prevents our knowing how far the resemblance is one of *family* and how far of *breed*, in general.

The same doubt exists respecting two tan terrier brothers (6 and 7) whose brains are similar, especially since they do not particularly resemble those of others of the same breed.

5. All of these dogs' brains are comparable in respect to the fissural pattern, both among themselves and with the feral *Canidæ*.

There is *something* which leads even the child to call all dogs by that name, whether they be terriers or St. Bernards, greyhounds or bull-dogs, poodles or mastiffs; just what this feature is, has not, so far as I am aware, been scientifically described; nor have I any suggestion to make; the case seems to be similar with their brains; I do not think I should mistake the brain of a dog for that of any other animal, but I cannot yet say upon what grounds, and am by no means sure that my diagnosis would be correct in all cases.

But it is evident that in order to ascertain whether or not there is any peculiar dog pattern, and if so, what it is, a much greater amount of material is required than is now accessible.

If nothing else, I have at least shown that no fissural pattern involving several fissures can be correctly known from the examination of a single brain, much less one side of such brain. The collection at Cambridge is very large as compared with that of most museums, but far too small for any final conclusions. I merely venture to express the hope that when we are able to compare say twenty-five brains of the same breed of dog, we may be reasonably sure what are its cerebral characteristics, and probably several hundred specimens will be required to demonstrate the essential features of the dog's fissural pattern as contradistinguished from all other *Canidæ*.

The immense cost of such a collection raises the question of the value of the result, and this is only part of a general question not sufficiently considered when scientific inquiries are begun.

If a thing is to be done at all, it can be accomplished far more completely and economically by one person or one institution than by several working separately or at different periods. I would therefore ask members of the Association to bear me in mind when they have or know of a dog of pure blood and well known character, which has outlived its usefulness; a careful transportation and death by chloroform will obviate distress on the part of both the animal and its master.

THE RELATION OF THESE VARIATIONS TO SCIENTIFIC PHRENOLOGY.*—In using the phrase "scientific phrenology" I place myself between two fires; for the professional phrenologist claims that all phrenology is scientific, while many scientists deny the compatibility of the terms. Let it be understood then, that I use phrenology in a general sense, and to avoid coining a new word, to indicate the study of the brain as an organ of the mind; and, further, that I am not in the least biased by the views of others, but am trying to learn the truth by a new method of investigation. In justice to myself also, it is right to state that I speak as an anatomist and not as a physiologist, much less as a psychologist. With all due respect for the latter classes of investigators, I believe that they have been hitherto building upon very slight foundations, and that an immense deal of hard work in the way of anatomical comparison must be done before they can be sure of the grounds upon which their experiments and conclusions can be based. Further, I hold that most of the facts already at hand are not of the right sort; and that we have begun at the wrong end and in the wrong way in our efforts to correlate brain and mind.

MENTAL ASSOCIATIONS OF PARTS OF THE BRAIN MASS.—Four methods may be employed in order to ascertain the mental associations of parts of the brain mass:

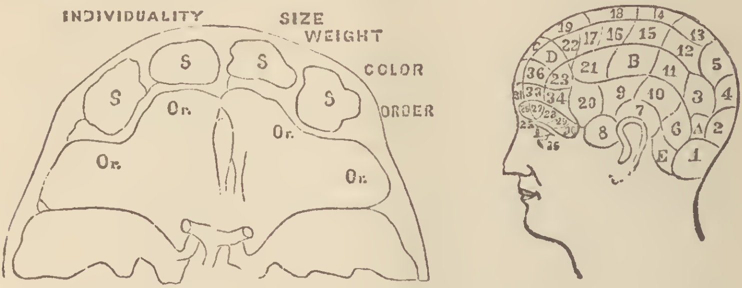
1. The Phrenological. The skull was accepted as an index of the form of the brain, and a certain number of cases of correspondence between cranial forms and marked characters was held to demonstrate the locality of mental faculties and propensities.

*This phrase is used by Gervais (Nouvelles Archives du Museum, tome vi, Pl. 9, Fig. 2). This author gives admirable lithographs of many brains and moulds of the cranial cavity, and suggests the value of a comparison of carnivorous brains, for the advancement of "scientific phrenology."

That this method is not satisfactory appears from the following considerations.

a. No definite and constant correspondence whatever exists between folds and fissures of the brain and the outer cranial surface.

b. Several important faculties are located over the frontal air sinuses, as pointed out by Dr. Cleland, from whom the accompanying figure (Fig. 27) is copied.*



c. No phrenologist has ventured to draw the accepted map of mental faculties upon the surface of the brain itself; and, from what we have learned, it is certain that what would fit one side would not fit the other.

d. No allowance is made for the extensive sheet of gray matter which covers the mesial surfaces of the hemispheres, and which, so far as has been shown, differs in no way from the rest.

e. To all appearance, the gray matter forms a continuous sheet, which may be more or less folded in the adult but was perfectly even at an earlier stage.†

f. By the failure (in several cases, though one is enough) on the part of the most expert phrenologist to determine correctly the character of an individual by examination of the head.‡

2. The Pathological. By comparing cerebral lesions with mental manifestations observed during the life of the individual. This is at present unsatisfactory, because:

* The lingering admirers of Phrenology. Popular Science Review.

† This is perhaps not so conclusive an objection as might at first appear; for the present non-recognition of lines of demarcation is no proof of their non-existence; and the experiments of terrier and others seem to demonstrate something like a localization of power in respect to *muscular action*; this, however, would not seem to require the same circumscription of area as in the case of distinct mental faculties.

‡ My views in respect to phrenology are given in "The Tribune Extra," No. 3, and my personal experience in "The Ithaca (N. Y.) Democrat" for Jan. 29, 1873. They will shortly appear in a republication of the lecture above referred to in the "Half-Hour" series of Messrs. Estes and Lauriat.

a. It has failed of absolute demonstration in respect to an apparently single organ, the cerebellum, for Dr. Hammond accepts neither the view of Flourens that it coördinates muscular action, nor that of Spurzheim that it is connected with sexual feeling, and concludes that it has no special function.*

b. The large number of cases in which aphasia coexisted with lesions of a tolerably definite region of the left hemisphere has not yet convinced the highest authorities that the mental faculty of language is there situated.

c. There is reason to suppose that peculiar mental conditions may exist when no cerebral lesion is recognizable, and that lesions may exist without mental disturbance.

d. Finally, Brown-Sequard concludes "from the study of every symptom of brain disease, that all parts of the brain may, under irritation, act on any of its other parts, modifying their activity, so as to destroy or diminish, or to increase and morbidly to alter it."†

3. The Experimental. This has been introduced by Fritsch and Hitzig, Beaunis and Nothnagel,‡ who, by galvanic or chemical irritation or destruction of certain cerebral regions of dogs, have demonstrated the existence therein of centres of action for different sets of muscles. This method promises great results, but, it may involve injury and abnormal action, and thus far has

* Quart. Journ. of Psychological Medicine, April, 1859.

† On the mechanism of production of symptoms of diseases of the brain, Archives of Scientific and Practical Medicine, vol. i, p. 117.

In this connection the following conclusions of Brown-Sequard (which I have but lately seen in the original, Feb., 1874) are of great significance: "An immense variety of symptoms in different individuals may be caused by a lesion in one and the same part of the brain; and the same symptoms may result from the most various lesions." Archives of Scientific and Practical Medicine, March, 1873, p. 259.

The above, together with the decided disbelief in the correctness of the generally accepted views of nervous physiology, which are elsewhere in the same journal expressed by the same high authority, should lead us to be cautious in our deductions from any single series of observations.

‡ FRITSCH AND HITZIG.—Ueber die electrische Erregbarkeit des Grosshirns. Archiv für Anatomie, Physiologie und wissenschaftliche Medicin, 1870, p. 300.

HITZIG.—Ueber die beim Galvanisiren des Kopfes entstehenden Störungen der Muskelinnervation. Archiv für Anat. Physiol. und wissenschaftliche Medicin, 1871, p. 716.

Weitere Untersuchungen zur Physiologie des Gehirns. Do., 1871, p. 771.

BEAUNIS.—Note sur l'application des injections interstitielles à l'étude des fonctions des centres nerveux. Gazette Médicale de Paris, 1873, Nos. 30–31.

NOTHNAGEL.—Interstitielle Injectionen in die Hirnsubstanz. Centralblatt für die med. Wissenschaften, 1872, page 705.

Experimentelle Untersuchungen über die Functionem des Gehirns. Virchow's Archiv, 1873, p. 184.

The above references are taken from Prof. H. P. Bowditch's excellent report on Physiology, Boston Med. and Surg. Journal, July 17, 1873, p. 79.

shown only a connection between cerebral substance and *muscular organs*, not of brain and mind.

The above method has been later employed by Ferrier,* who, however, used faradic instead of galvanic electricity.

Dr. Ferrier's results are interesting in the highest degree, and it is only to be regretted that he has not at once published a diagram of a brain, so that all may know to what parts he refers in his description.

It is worthy of note that in the following expression he jumps at no conclusions respecting the localization of *mental faculties.*

"There is reason to believe that, when different parts of the brain are stimulated, ideas are excited, but it is difficult to say what the ideas are. There is, no doubt, a close relation between certain muscular movements and certain ideas."

But the results of such experiments can hardly be accepted as indicative of the localization of mental faculties in the human brain, or that of any animal than the one experimented upon, until it is shown that homologous folds exist in both; and even then the fact that the same faculty, for instance, *combativeness*, is manifested by a dog with its jaws, by a horse with his hind legs, by a bull with his horns, and by human beings, with hand or foot, or only with tongue, renders the practical *phrenological* application a very difficult one. The following suggestion was made by me a year ago (lecture on the brain above referred to).

"To apply galvanic stimulus to the supposed organs of prominent and distinct faculties, either indirectly, through the skull, or directly, in cases of accident; perhaps it is not too much to suggest that the *experimentum crucis* could be tried, if an enthusiastic believer would allow himself to be trephined, through a few protuberances. We could then witness the manifestation of friendship or combativeness, as the subject clasped the operator in his arms or planted a blow between his eyes.

It cannot be denied that trephining is one of the perilous operations, but a healthy man would have a fair chance; a criminal would do well to accept the risk in case of possible slow strangulation, and should he die during the operation, it would merely anticipate by a score of years the method of execution, namely,

*FERRIER.—"Experimental Researches in Cerebral Physiology and Pathology." British Medical Journal, April 26, 1872. Also: "A new method with the brain;" read before British Association for Advancement of Science, 1873, and printed in "Nature," and in "Popular Science Monthly" for Dec., 1873.

by an overdose of chloroform, to which I believe we shall be compelled to resort, in the interests of decency, humanity, and even artistic effect."

But while convinced that this method of investigation will throw great light upon the question of the correlation of brain and mind, I am by no means confident that it will demonstrate the localization of mental faculties in certain cerebral folds. On the contrary, although satisfied that my present material is too small for final conclusion, I am more and more inclined to think that a cerebral hemisphere acts as a unit, either singly or with its fellow; that, other things being equal, a greater number and depth of fissures indicate a greater mental or bodily power, and that the actual number of the fissures has only a *general functional significance, analogous to coils of intestine, or corrugations of mucous membranes;* but that like these, or like the peculiar turns of horns and the arrangement of turbinated bones, their arrangement in what is called the fissural pattern may be fairly accepted as indications of *zoölogical relationship*, more and less remote. The extent of their value in this regard must be ascertained by much more extensive comparison than has been made.

4. Cyno-phrenology. The method here advocated is, in theory, that of the phrenologists, but its practice differs therefrom in two important respects: *a.* In employing the brain itself for comparison, in using large numbers, in comparing the two sides, and in keeping the brains for such study as is impossible from figures. *b.* In employing not human, but canine brains, upon the grounds of their simpler fissural pattern, their smaller size, and consequent easier preservation in large number, and the possibility of an accurate acquaintance with the mental characteristics of the dogs. At present we are well acquainted with the natures of our family, our friends, and of public men; their brains are rarely at our disposal for scientific investigation; so we study the brains of paupers and uncultivated persons whose characters are known to us either not at all or very imperfectly. With dogs, the brain and the mind of the same individual are at our disposal; while lateral, epochal, individual and sexual variations, together with those appertaining to families and breeds, may be more easily observed and separated.

I have records of the habits and disposition and mental attainments of several dogs, but the material is far too slight for anything like a scientific deduction. I even hesitate to associate the great width of the supersylvian fold of a bulldog, with his fighting powers, for his *disposition* was gentle enough.

Even Distribution of Fissures.—I cannot help thinking that at least one of the elements of the fissural pattern is the subdivision of the surface into approximately equal areas. This is best demonstrated by projecting the surface of a hemisphere upon a plane. But the only brain on which I have as yet done this is less satisfactory than I expected; and I shall hope hereafter to offer sections of the hemispheres which will better indicate both the distance between the fissures and their depth.

If particular folds are the organs of either mental faculties or distinct groups of muscles, and if as such organs they are circumscribed by the intervening fissures, then how can we explain the following facts?

1. That these folds are generally continuous around the ends of the intervening main fissures.

2. That even where "islands" are formed by the extension of branches or by secondary fissures, there was a time when these surfaces were continuous upon the same level.

3. That no one has yet demonstrated any structural lines of demarcation corresponding to the fissures.

4. That there may be differences between the two halves of the same brain equal to or even greater than those which distinguish individuals or even species.

The zoologist and comparative anatomist would not hesitate to call attention to the greater or less width of a certain fold, and would regard it as of possible taxonomic value; but the cautious physiologist would certainly shrink from the inference that this was conclusive proof of the greater or less power of certain muscles or mental faculties; and he would be yet more loath to infer that the apparent obliteration in many dogs of the posterior leg of the front or lowest fold (which in fox intervenes between the *sylvian* and *ectosylvian*) indicated the absence of either the muscles or the faculties which the fox exercises through it; or even to infer that the apparent transfer of the anterior leg of this fold in hyæna, to behind the *sylvian* fissure indicated a real transfer of a mental or muscular "organ;" although, should the fissural arrangement prove constant, it would be unhesitatingly accepted as of great taxonomic value.

Plate 1. FORMATION AND NOMENCLATURE OF FISSURES IN CARNIVORA.

Fig. 3. Fox, *V. fulvus.* ♂ adult.

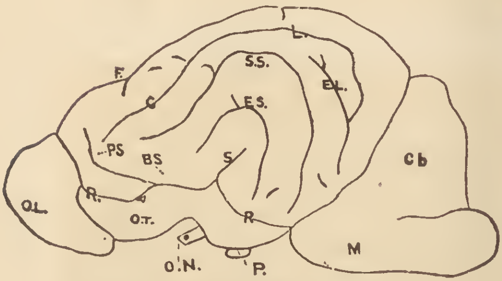


Fig. 4. Fox, *V. fulvus.* ♀ (513.)

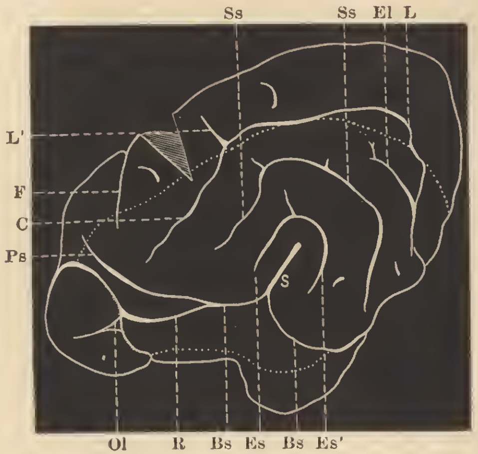


Fig. 5. Fox. Same as 4, projected on a plane. (See page 218, note.)

Fig. 6. Fœtal Wolf (*Canis occidentalis*): four days before birth. (530.)

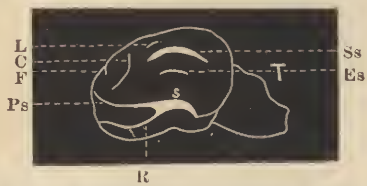


Fig. 7. English Terrier: one day. ♀ (532.)

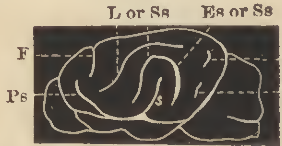


Fig. 8. Weasel. *Putorius Noveboracensis.* Nearly grown. (528.)

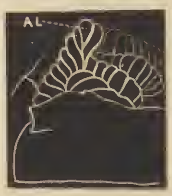


Fig. 1. Appendicular lobule of Cerebellum, left side, of Chinese dog. (p. 217.)

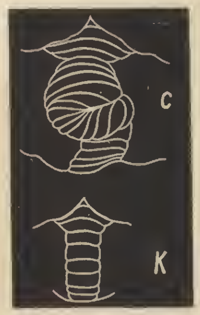


Fig. 2. Median lobe of Cerebellum of Kitten (K) and Cat (C), showing contortion during growth. (page 221.)

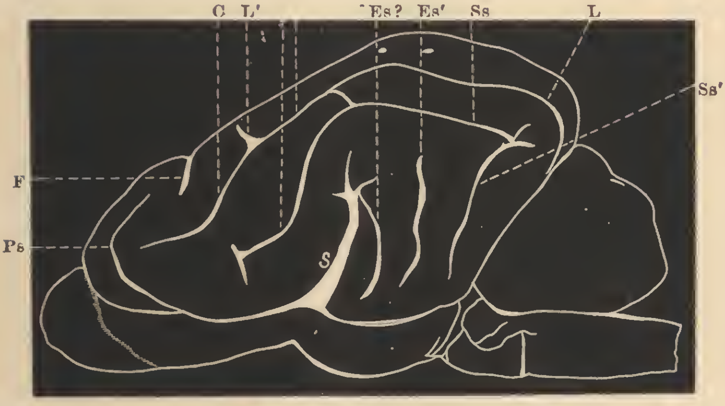


Fig. 9. *Hyæna vulgaris*, ♀ old. (12.) (p. 229.)

Fig. 10. Bear: *Ursus Americanus.* ♀ one year. (502.) (p. 231.)

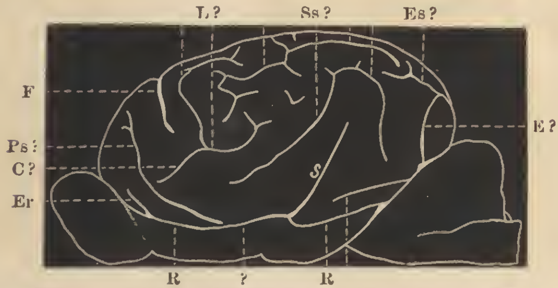


Fig. 11. Raccoon: *Procyon lotor.* Adult. (577.) (p. 225.)

(I am in doubt respecting most of the fissures in *Ursus* and *Procyon.*)

Plate 3.

Lateral Variation in Dogs and Cats.

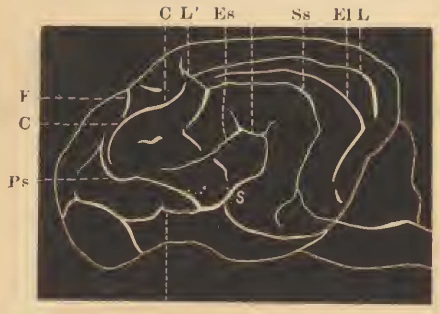


Fig. 12. Small bl'k and tan Terrier, ♀ (left side) six months. (511.)

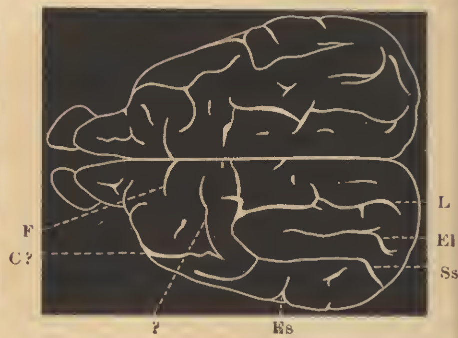


Fig. 14. Young Pointer and Shepherd, ♂ (14.)

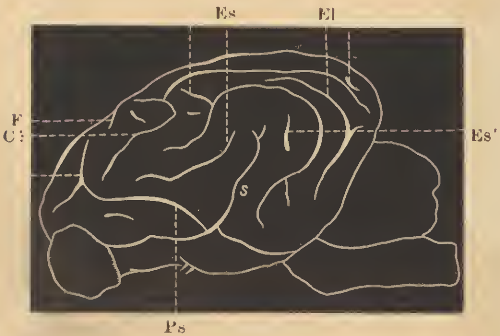


Fig. 13. Same as fig. 12 (right side reversed).

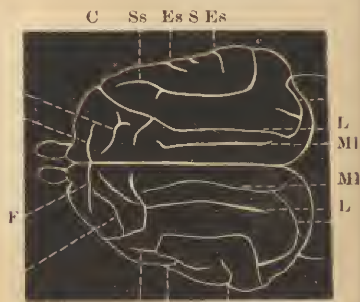


Fig. 15. Cat. Half grown, ♂ (20.)

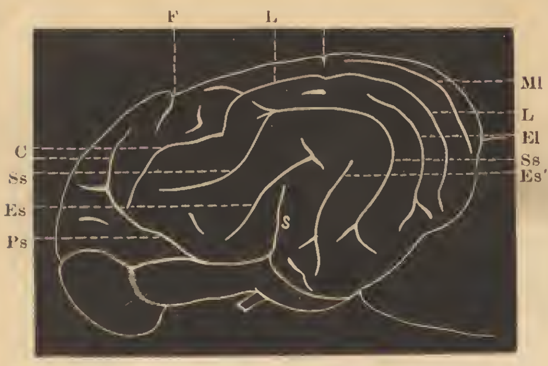


Fig. 16. Greyhound, one year, ♂ (526.) (p. 229.)

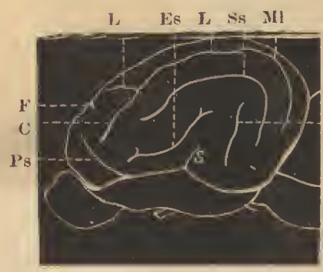


Fig. 17. Cat, adult. (p. 232.)

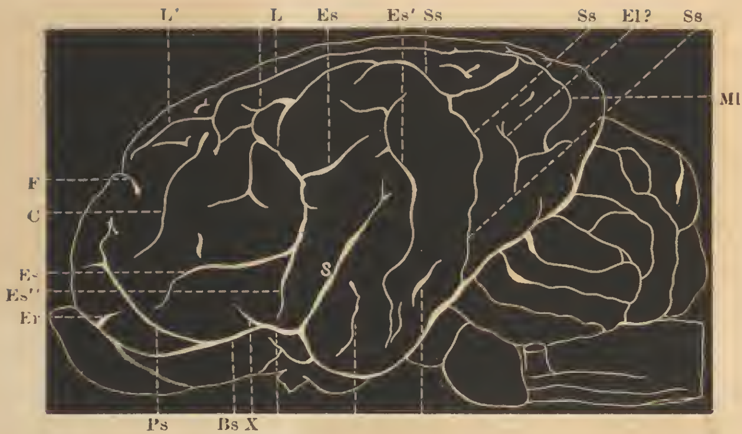


Fig. 18. Lion. *Felis Leo*, var. *Asiaticus*: seventeen months. Cerebellar lobes shown in part. (510.) p. 233.

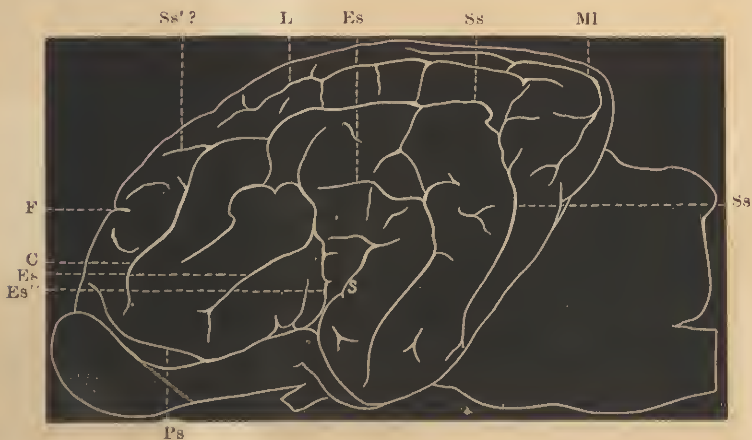


Fig. 19. Lion. *Felis Leo*, var. *Africanus*, ♂ seven and one-half months. Cerebellum in outline only. (552.) p. 233.

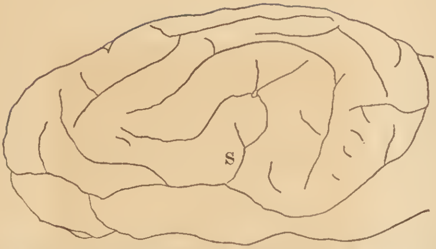


Fig. 20. Pomeranian dog, ♀ adult (I). (Mother of 21, 22, 23.)

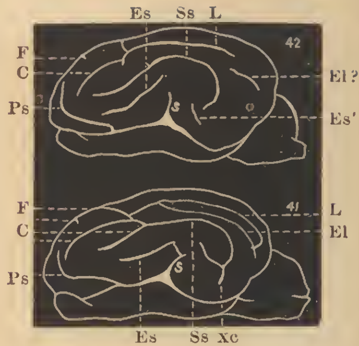


Fig. 24. (41 and 42) Pomeranian pups, ♀ three days.

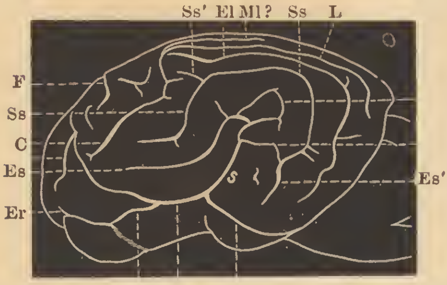


Fig. 21. Pomeranian pup, ♀ five weeks. (3)

Fig. 22. Pomeranian pup, ♀ four and one-half weeks. (2)

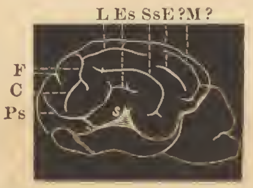


Fig. 23. Pomeranian pup, ♂ fifty-four hours. (4)

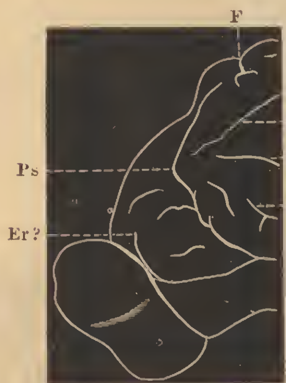


Fig. 26. Newfoundland, ♂ adult. Olf. lobe exposed.

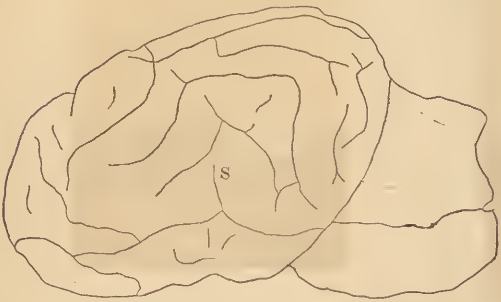


Fig. 25. English terrier, olf. lobe hidden; three and one-half years. (7) (p. 228.)

Fig. 1. Left brain, left hemisphere: weight, ,182.

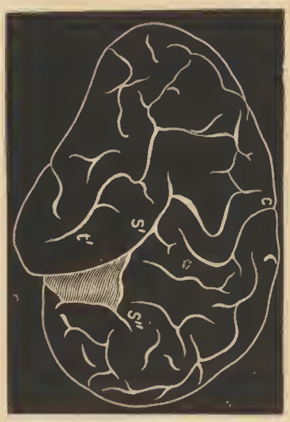


Fig. 2. Left brain, right hemisphere: weight, ,190. (drawn after drying.) See page 250.

Weight of left brain, ,372.

Fig. 3. Right brain, left hemisphere (the dotted line indicates a part of the frontal lobe which was destroyed): weight, ,196.

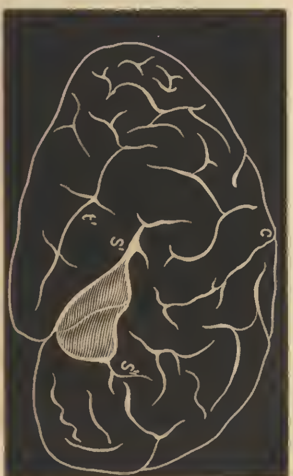


Fig. 4. Right brain, right hemisphere (drawn after drying): weight, ,200.

Weight of right brain, ,396.

All the facts indicate that while it is not impossible or even improbable that different areas of the cerebral surface may be in functional relation to either movements or mental operations or both, yet these areas are not *always, if ever, circumscribed by the fissures;* that the fissures merely increase the amount of gray matter wherever they are; their signification being rather quantitative than qualitative.

This question might be decided by Dr. Ferrier's method, exploring not only the free surface of the folds but also the hidden walls of the fissures.

Explanations of Figures.*—With two exceptions (Figs. 10 and 13) the brains are shown from the *left* side, and all the drawings are made from specimens hardened, and thereby shrunken, in spirit. The olfactory lobe is given in outline; also the cerebellum and medulla oblongata: but neither the nerve roots, nor the cerebellar convolutions are indicated. As stated on page 218, note, each fissure is drawn as it appears to the eye placed over *it* perpendicularly to the surface on which the brain rests.

Figures 3, 4, 20, 22, 25, showing the fissures dark on a white ground, have been kindly loaned to me by the "N. Y. Tribune," from those which illustrated the report of my lecture on "The Brain, and the present scientific aspect of Phrenology," printed in the "Tribune" Extra, No. 3: a few inaccuracies which could hardly be avoided in the hasty preparation for the press, have been since corrected.

The remaining figures, in which the fissures are shown white on a dark ground, have been drawn on wood and cut by Mr. Philip Barnard of Chicago (now a student in Cornell Univ.), to whose patience and accuracy I gladly bear witness. All the drawings were made by me from specimens which I had prepared.

The fissures are lettered uniformly throughout.

S—Sylvian.
Bs—Basisylvian.
Ps—Presylvian.
R—Rhinal.
Er—Ectorhinal.
F—Frontal.
C—Coronal.
Es—Ectosylvian.
Es′—Its posterior branch.
Esv—Its ventral branch.
Ss—Supersylvian.
Ss′—Its medial branch.
L—Lateral.
L′—Its medial branch.
El—Ectolateral.
Ml—Medilateral.

* The numbers in parenthesis refer to the Catalogue of the Neurology and Embryology of Domesticated animals at the Museum of Comparative Zoology.

Lateral Asymmetry in the Brains of a Double Human Monster. By Burt G. Wilder, of Ithaca, N. Y.

[The figures form plate 6 at the end of the preceding paper.]

It is generally known that the right and left hemispheres often present considerable differences in the details of the cerebral pattern; but very rarely do we find figures or detailed descriptions which indicate the extent of this lateral variation, although its existence would seem a serious difficulty in respect to phrenology. As remarked in a previous paper no brains of different individuals can be so closely allied as those of the same individual, and a study of these must serve to check our estimates of the zoological value of fissural variation between species; next in value for this purpose would usually be ranked the brains of twins or, with animals, brothers and sisters of the same litter; but an intermediate stage of relationship is presented by double monsters, like the one described in the next paper, and as their brains are rarely preserved or figured, I have thought them worth recording.*

The brains were bisected soon after extraction; each was weighed and each cerebral hemisphere placed in spirit upon its mesial surface; being quite soft, they became unnaturally flattened in the process; they were drawn after hardening and the two right hemispheres shrank while drawing, from evaporation of the spirit, so as to lessen their area and to expose the island of Reil to an unnatural extent, as appears in figures 2 and 4. This prevents the otherwise interesting comparison of the four hemispheres in respect to the *length* of the fissures, without reference to their depth; and in respect to the total area of the outer surface of the hemispheres.

But the fissures themselves and their connections are unchanged, and certainly present some striking differences whether the two brains are compared together, or the two halves of the same brain. I have lettered only the *sylvian* (S′), its *ascending branch* (S″), the *first temporal* (t′); and the fissure of Rolando or *centralis* (C).

The temporal (t′) of the right brain, left hemisphere, is in two portions, the separation occurring at a point corresponding with a transverse fissure in the other hemisphere; and although Ecker

* I hope on a future occasion to present a detailed comparison of the four hemispheres of several double-headed calves and pigs, which are now in the Museum of the Cornell University.

says nothing of it (*op. cit.* 62), yet some fœtal brains in my possession indicate that there may here be two fissures which originate separately but usually unite; the case may be compared with that of the *lateral* and *coronal* in *carnivora*. (See page 227.)

I do not feel sufficiently sure of the correctness of the generally received designations of the other fissures to compare them individually, but it is evident that all the fissures differ greatly as to length, direction, branches and connections, and that the smaller fissures vary considerably in number, giving an *appearance* of fissural complexity in the following order. 1. Left brain, left hemisphere; 2. Left brain, right hemisphere; 3. Right brain, right hemisphere; 4. Right brain, left hemisphere.

It is worth noting that, excepting with the left brain, right hemisphere, this order is inversely to that of the weights, as if by way of compensation; also that the two hemispheres of the left brain present the two extremes of fissural complexity, while the intermediate conditions are seen in the right brain.

Furthermore, it may not be too much to associate the greater weight (,024. grams) of the whole left brain over the right, with the fact that the corresponding part of the double body is larger than the right, and the median third leg is thrown over toward the right side, as if it were more fully a right leg of the left child than a left leg of the right child.

The combined weight of the two brains is ,768. which is to that of the bodies, 5,000. about as 1 to 6½, which is the average ratio in females at birth, according to Tiedeman; that in the male being, according to the same authority as 1 to 5·85; as quoted in Quain's Human Anatomy, ii, 570. This monster is apparently of the male sex.

The Papillary Representative of Two Arms of a Double Human Monster, with a Note on a Mummied Double Monster from Peru. By Burt G. Wilder, of Ithaca, N. Y.

The double monster here referred to was still-born, *at term*, in March, 1873; aside from the malformation it was of good size and appearance; the left spine was found to be fractured, and it may have died during parturition which was long and difficult, although the mother recovered without trouble.

Having preserved all the viscera (including the brains, which were described in the previous paper), it is my intention to prepare a detailed account of the case in connection with several other double monsters in my possession, so I will merely mention that it weighed about 5,000. grams (about eleven pounds), and measured about twenty-two inches when the legs were extended.

There are two stomachs, symmetrically disposed, as usual in such cases; the small intestines continue independently to near the cæcum; this, the colon and rectum are single, the latter terminating at an imperforate anus, just above (behind) the genitals; there are two hearts, and two pairs of lungs; four kidneys and two bladders; the sex is apparently male, but the testes have not entered the scrotum, and I have not yet looked for them among the viscera.

As seen in the figure, its heads are separate and complete, the right larger then the left, as with the corresponding brains; the opposite limbs and sides of the compound body are somewhat unsymmetrical, the right child seeming to constitute more than half of the whole; the hands and feet are quite well formed but there is an extra right pollex; further details will be given hereafter.

So far this specimen nearly resembles that so well described and figured by Professor Jeffries Wyman in the "Boston Medical and Surgical Journal" for March 29, 1866.*

There is also a third and median and morphologically symmetrical leg coming off from the pelvis, and possessing a partly double foot with a median *primus* (great toe) bearing a nail upon each side, and seven other toes of which four seem to belong to the right, and three to the left, moiety; but this left foot belongs of course to the right child, and the right belongs to the left child which thus claims four and a half of the eight toes.

The leg and foot are less regular and symmetrical than in Wyman's case, and the whole limb is swung out toward the left as if more under the control of the right child, concomi-

* The figure is reproduced in Dr. S. J. Fisher's essay upon Diptoteratology, p. 72, and figs. 53 and 54, the description is there quoted in part, and in full in Prof. J. B. S. Jackson's Catalogue of the Warren Anat. Mus. of Harvard University.

tantly with the greater bulk of the right brain (see preceding paper).

The point to which I wish to call particular attention is the existence of a minute papillary representative of the missing arms, corresponding to the legs which are represented by the fused and median limb; this is a papilla about ·005, in length and slightly constricted at the base; the surface is slightly wrinkled and a few short hairs spring from the tip; it is wholly tegumentary, and its cavity contains only loose connective tissue.

Fig. 1. Dicephalous Monster, from behind; 1·6 of natural length.

Its nipple-like appearance, and its location upon the line of junction of the shoulder regions of the two individuals, suggested its being the result of a fusion of the left nipple of the right child and the right nipple of the left child (the other two occupying their normal positions upon the pectoral regions), but it is *imperforate;* and what is conclusive, the real nipples, though small and hardly projecting from the surface, occupy places upon the sides of the junction-line, the right one (left of right child) being

·030, and the left (right of left child) ·025, behind the median papilla, and at a distance of ·025 apart; an elongated mammary gland underlies the left nipple as indicated by the slight elevation in fig. 2, A, but no such is apparent under the other.

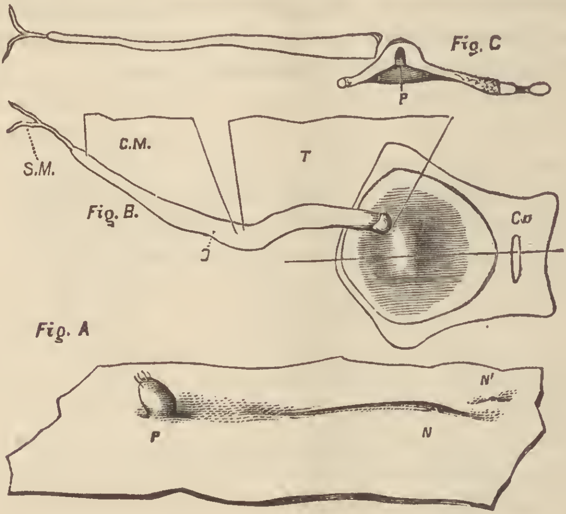


Fig. 2. A. Integument bearing the papillary limb P, and the two nipples N, N'.
B. Median scapula and clavicle from above.
C. The same from the side, the scapula divided near the middle line; all of natural size.

Immediately beneath the integument upon the line of junction are two bones whose position in reference to the papilla is approximately shown by the dotted outline in fig. 1; while their forms and connections are shown in fig. 2, B and C. The longer bone is evidently a median and nearly symmetrical clavicle; it is about ·045, in length, is wholly ossified, and presents at its hinder extremity an appearance of epiphysis, which is attached to the anterior slope of the scapular elevation by ligaments, without any synovial capsule; its anterior extremity gives off a slender tendon which bifurcates at a distance of ·005, into the tendons of the two *sterno-mastoid* (?) muscles; into each side are inserted two muscles, the *cleido-mastoid* occupying the anterior, and the *trapezius* the posterior half. The enclosed spaces C M and T indicate the attached ends of the *cleido-mastoid* and *trapezius* muscles of the right individual; the elavicle is strongly curved toward the left individual, as seen from behind, but as seen from the side its outline is nearly straight, fig. 2, C.

The scapula is a nearly symmetrical disk of bone with a cartilaginous border which is narrow in front, projects as an angle upon each side, and is broader behind where it is closely connected with a transverse bar of cartilage, excepting an elongated gap upon the middle line; the scapular disk is convex upon its dorsal surface, rising near the anterior border into a decided elevation or tubercle corresponding with a deep pit P, upon the concave deep surface, as shown in the section C.

I am not prepared to express a decided opinion as to the nature of the cartilaginous bar; but have no doubt that the disk represents the fusion of the inner or vertebral or proximal moieties of the left scapula of the right child, and the right scapula of the left ehild, at a point *proximad* of the glenoid cavities so as to leave only portions of the acromial spines to unite and form the elevation against which the clavicle abuts; to the various borders of the seapula are attaehed muscles, which seem to represent the two *rhomboidei*, the *serratus magnus*, the *levator anguli scapulæ*, and the *omohyoid;* but as I am still in some doubt respecting the *pectoralis major*, and the attaehments of the *teres major* and *latissimus dorsi*, I will defer an aceount of them to another oeeasion; when, too, the absence of a sternum and the apparent anomalous direction of the clavicle can be accounted for.

In general, however, it is evident that the condition of things is like that in Prof. Wyman's ease, exeepting that the separation of the two individuals at the shoulders is less complete; or the union is more so.

The result is to reduce so far the median and third arm, that instead of being obviously and unmistakably such it is a mere papilla which but for its position and its relation to the underlying bones would never be regarded as a limb, much less as two arms; yet it is evident that it is just as much so, *morphologically*, as is the earliest pad-like rudiment of a limb in the developing fœtus; for it is possible to conceive of a complete series of intermediate conditions with Wyman's case at one extreme and this at the other.

It would seem therefore that, in any such system of classification of monsters as that proposed by Dr. Fisher, our monster should rank as *Dicephalus, tribrachus tripus; op. cit.*, p. 71.

But the question arises whether the name could be retained in case of a still further reduction, so as to leave no external evidence of a median limb; and while this may be of less practical importance in respect to monsters, yet it is akin to the general problem "what constitutes a digit or dactyle" briefly indicated by me.*

NOTE ON A MUMMIED DICEPHALUS FROM PERU. — Dr. Chas. S. Swazey of New Bedford has kindly allowed me to bring some photographs of Peruvian relics, and among them is one of a human dicephalus, closely resembling our specimen; but as it

is in a sitting posture and shown from in front, the existence of median limbs is merely to be inferred, the left foot is partly hidden by the right, and the three tibial (inner) toes of the right are turned down. It seems, from this, that monsters occurred among the ancient Peruvians, and that they were not consigned to scientific investigation, but duly mummified.†

*Intermembral Homologies, p. 63; Proc. Bost. Soc. Nat. Hist., vol. 14, 1871.

†It is stated in Spencer's "Descriptive Sociology" that the "Huacas," or sacred objects of the Peruvians included twins and monsters.

The Habits and Parasites of Epeira riparia, with a Note on the Moulting of Nephila plumipes. By B. G. Wilder, of Ithaca, N. Y.

The large garden spider with black and yellow abdomen, which is very common in certain parts of the south, and less abundant at the north, was first, so far as I know, described and figured only by Hentz.*

Although that author's description is very brief, the spider is readily identified, and it may be better to defer a fuller description until a male is secured; at present there are some points in its economy worthy of investigation, and I will here indicate them, first quoting in full Hentz's account of the species.

"*Description.*—Black, cephalo-thorax covered with silvery-white hairs; abdomen barred with bright yellow spots and dots; thighs usually bright rufous at base, except the first pair. Of a large size, seldom small.

Observations.—This remarkable species usually dwells on the margin of waters where it makes a web of strong threads, in which large *Libellulæ* and *Melolonthæ* are often caught. The abdomen of the female is flat in the early part of the season, and it is not till August that, being distended with eggs, it assumes the oviform shape. Its cocoon is conical, as large as a small plum, like a pear hanging down. Whenever opened it was found full of young spiders instead of eggs. Is it viviparous?

Habitat.—The United States."

During the war I had the opportunity of studying certain features in the economy of this species, which at the time, I imagined to be wholly undescribed, and in "Harper's Monthly" for March, 1867, under the title of "200,000 spiders," I gave descriptions and figures of the female *E. riparia*, of her net and of the cocoon; also of presumed ichneumonidian and chalcidian parasites found therein. And as nothing has since appeared respecting it, I will here give an abstract of the above mentioned paper, together with some additional observations respecting the escape of the young from the cocoon.

*Boston Journal of Natural History, 1847, v, 468, pl. xxx, fig. 5, under the name of *E. riparia*.

On the 21st of March, 1865, on James Island, just south from Charleston, South Carolina, I found suspended in a bush a pear-shaped cocoon (fig. 1), like that described by Hentz. Between

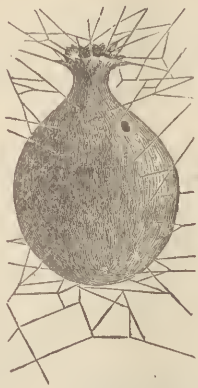


Fig. 1. Cocoon of Epeira riparia; nat. size.

the above date and April 2d, I found in the same locality, and chiefly near a ditch, two hundred and five similar cocoons.

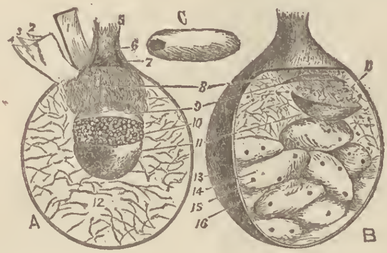


Fig. 2. A. Vertical transverse section of cocoon of *Epeira riparia*, containing only the eggs of the spider.

B. The same showing the cocoons of the ichneumon, which destroyed the eggs, and which are themselves destroyed by chalcidians.

C. Cocoon of ichneumon from which the insect has escaped.

1. Outer, and usually glazed, coat of the cocoon. 2, 3, 4. Second, third and fourth, or inner coats, separated from each other. 5. The pedicel. 6. Looser interior of pedicel. 7. Thickened base of pedicel. 8. Suspensory of the egg-cover. 9. The egg-cover. 10. The eggs partly exposed by separating the cover from the cup. 11. The cup. 12. Loose silk surrounding the cup. 13. Hole made by escaping ichneumon. 14. Ichneumon cocoon. 15. Holes in the ichneumon cocoons made by the chalcidians. 16. Corresponding holes in the spider's cocoon.

The cocoon is usually pear-shaped, ranging from ·015, (15 millimeters) to ·022, in transverse diameter, and from ·025, to ·032, in length. The wall averages ·000,5 (½ millimeter) in thickness, and usually consists of four concentric and closely united coats or layers of silk, which are nearly equal in thickness and compactness, the outer one (1), however, being usually smoothly glazed without, so as to crackle like thin paper; sometimes there are but three coats, and in some of these cases, the outer one is not glazed but soft and velvety; the coats thin out over the pedicel, but not by well-defined edges.

At the top of the cocoon is a *pedicel* or *stem* (5), hollow and loose in texture (6) above, but broader and denser below, where it is concealed by the body of the cocoon, and having its lower surface or base very firm, like a silken disk (7).

The contents of the cocoon are a mass of loose, reddish silk (12) attached above, about the base of the pedicel and apparently also to the inner coat (a special portion of this loose silk, like a *cushion* (8) attached to the base of the pedicel); a kind of *saucer* (9) of very delicate silk, which is inverted, and suspended by the cushion above mentioned; a *cup* (11) of the same delicate silk suspended to the lower border of the saucer (which thus forms its cover) by a few fibres of loose silk; a mass of *eggs* (10), from five hundred to two thousand two hundred in number, enclosed within the cup (at the time these were found, these eggs had evidently hatched, for in their place were found large numbers of little fragments of broken shells); many little round bodied spiders, never, in the earlier weeks, less than five hundred in number; which, when the cocoon was opened, came tumbling out, each swinging by its own little thread, and "looking like so many chickens hung by their tails" (Harper's Magazine, 1866, p. 452, and fig. 12).

I have never witnessed the making of a cocoon; a spider afterward taken near Boston, Mass., was just finishing her work at 6 A.M. of Sept. 26, by attaching lines from the cocoon to surrounding objects. But it may be inferred that the pedicel is first formed, and firmly secured by strong lines in all directions excepting downward; that to its lower surface the spider affixes the cushion of loose silk; and to this the inverted saucer; the eggs are now expressed upward into this, while the spider hangs back downward below it; the cup is now formed under and about the eggs; and then around the whole is spun the loose mesh of silk which serves the double purpose of protection to the eggs and the spiders, and as a primary habitation for the latter before they escape and make nets of their own; finally, the outer wall is formed in three or four consecutive layers, and the cocoon is braced by strong lines passing to the surrounding twigs.

From the above account it appears that the cocoon must be formed and the eggs laid in the previous summer; and that in South Carolina, the eggs are *hatched as early as the 21st of March;* but although by opening a cocoon every day or two, I satisfied myself that each of them did really contain from five hundred to two thousand living spiders, and although they were kept exposed to the sun and occasionally sprinkled with water, yet during all the time I kept them, namely, until June 15, *not one of the entire cocoons was opened by the inmates.* On and after the 10th of May, however, they sometimes came out of holes cut in the cocoons, or through openings, hereafter to be described. But first it is important to state that from a single entire cocoon found at Ithaca, N. Y., the spiders escaped through a hole made by themselves near the base of the pedicel, on the 14th of June, 1873; so perhaps, but for an accident which destroyed them, those at the south would soon have made their way out.

The fact, however, remains that the young of *Epeira riparia* live together for many weeks in a confined space, and with no *food excepting one another.** That they do eat each other is certain; first, because in cocoons opened later in the season, the spiders were found to be fewer in number, but larger in size; and second, because they were seen to do it, even when out of the cocoon and supplied with other food (as blood) which they seemed to relish. There never was any fighting, however; the smaller and weaker seemed to understand that for the good of the species (*pro bono publico*) they must be devoured by the larger and stronger, who performed their part "doucement et sans cholere."

It is evident that here is an opportunity for noting the working of "natural selection," upon a large scale; for out of the five hundred young who are hatched, comparatively few can reach maturity, else the country would soon be overrun with them; the fact being that although the species is widely distributed, yet I

*Three cocoons of this species were brought to me Feb. 26, 1874; and the young spiders are hatched; without speculating as to the time that may have already elapsed since the hatching, this gives us nearly four months during which the young remain confined; and it will appear that the cocoon itself must keep out the cold as efficiently as the egg shells, pupa cases and cocoons of insects which appear later in the season.

never found them in such abundance in other parts of the south, and saw only eight cocoons between Charleston and Eutaw Springs, South Carolina, searching the woods bordering the road both going and returning.

Of the four hundred and six cocoons obtained on James Island in the spring of 1865, only one hundred and thirty-four were *entire*, and presented no opening whatever. My notes state that one hundred and ninety of the others were *pierced*, but by what is not mentioned and I do not now venture to conjecture; but no spiders came out of these before May 10, although the openings were certainly similar to those made by the spiders in the cocoon mentioned on page 260.

Of the remaining eighty-two cocoons, fifty-nine were *torn*, in one or more places, and through the rents projected loose silk; having once "seen a little bird about the size of a sparrow, fly at a cocoon hanging in a tree, make one or two quick pulls and then retreat," I am inclined to think all these rents were so caused; and as these attacks would usually open the cocoon without injuring the inmates, I drew the inference that this might be a provision of Nature, like the fertilization of flowers by insects, by which the invasion of the cocoon should really permit the continuance of the species; that this is not the only means of egress has been since shown in the case mentioned upon page 260.

Parasites.—The remaining twenty-three cocoons presented openings of one, and usually of two sizes; the larger about ·001, and the smaller ·000,3 in diameter. Some of these cocoons contained a few spiders, but usually only empty shells; while the original contents were in all cases crowded to one side and upward by a mass of small oblong cocoons (14) of a whitish silk, and more or less firmly united by threads. In one spider's cocoon, some of the smaller cocoons were empty with a hole in one end corresponding in size and location with the larger holes in the spider's cocoon (13); three were entire and each contained fragments of a single insect, apparently an *ichneumon*, of which I have at present no fragments which can be specifically identified. The small cocoons in all the other twenty-two cocoons in this series presented no large holes but instead, many small holes like pin-pricks (15) corresponding to the smaller holes in the spider's cocoons (16); and in all these pierced cocoons were fifteen to twenty little black insects, some motionless (*pupæ*), others crawling actively about (*imagines*), which are undoubtedly chalcidians, but as yet undetermined; all such cocoons contained also the empty pupa skins of the ichneumons, which, having destroyed the spiders before or after hatching, had been themselves devoured by the chalcidians.

The chalcidians range from ·001, to ·002, in length. The ichneumons range from ·005, to ·006, in length. Their pupa skins from ·006, to ·008, and their cocoons from ·007, to ·010, in length and ·003, to ·004, in diameter.

In the article above quoted, are given figures and descriptions of these parasites and some suggestions as to the manner of their entrance to the cocoon; but it is evident that a careful investigation will be needed in order to elucidate fully the history of this spider and its enemies.

NOTE UPON THE MOULTING OF NEPHILA PLUMIPES.—Mr. Blackwall* has clearly described the moulting of *Epeira calophylla*, and

Figs. 3, 4. Moulting of Nephila plumipes.

called attention to the fact that the first separation of the integument occurs along the border of the cephalo-thorax and not upon the median line. Having witnessed this very often with *Nephila*

*Trans. Linn. Soc., vol. xvi, p. 473, and spiders of Gr. Br., p. 7.

plumipes, I am able to confirm his description; and as no illustrations of the process are known to me, I offer here two representations of *Nephila* drawn by me from the same individual, while partly extricated (fig. 3), and while hanging and drying preparatory to mounting to her net (fig. 4); the position must assist the flow of fluid from the abdomen into the limbs and cephalo-thorax.

I have "biographies" of several individuals of this species which were isolated and watched for a greater or less length of time, in a few cases from soon after hatching to the adult condition; and I have observed remarkable differences of disposition and habit, quite comparable to those commonly ascribed only to human beings and the higher animals; there seem to be truly psychological individualities even among spiders.

Fig. 5. Nephila plumipes, a few days old; natural size and enlarged.*

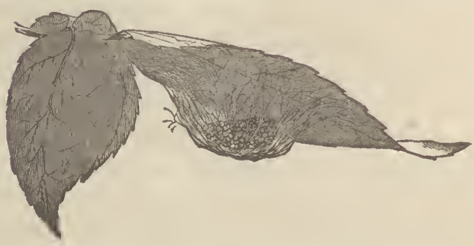


Fig. 6. Cocoon of Nephila plumipes, or loose silk attached to the lower surface of a leaf.

*This, with figs. 3, 4 and 6, and fig. 1 of the following paper, are electrotypes of cuts in my article "Memoirs of a Cripple," in "Our Young Folks" for Sept., 1866, furnished me at cost by Messrs. J. R. Osgood & Co.

THE NETS OF EPEIRA, NEPHILA AND HYPTIOTES (*Mithras*). By B. G. WILDER, of Ithaca, N. Y.

MOST *Epeiridæ* ("garden" spiders or "geometrical" spiders) construct a net in the form of a nearly circular disk which is suspended at various angles, but probably never quite vertical or horizontal, although the former position is generally predicated of the ordinary species, and the latter of *Tetragnatha* and some species of *Epeira*. The net consists of a spiral viscid line laid upon a framework of dry radii which converge to a point which apparently coincides with the centre of the disk, but may vary a little therefrom, and, according to Emerton,* is usually nearer the top than the bottom. In some cases, and perhaps in all, the radii are first connected by a *primary spiral dry* line at greater intervals than the secondary viscid line; this is begun at the centre and completed at the periphery, and according to Emerton (*op. cit.*, 479) is removed as the viscid line is laid on (it is permanent in *Nephila*); the viscid line is begun at the periphery and completed near the centre; the spider takes position at the centre upon the lower surface of the net, and always with its head downward. The net of *E. vulgaris* is figured by Emerton (Am. Nat., vol. ii, Pl. 2), that of *E. riparia* by me (Harpers' Magazine, March, 1867, p. 463), and those of several British species by Blackwall, in his great work, "Spiders of Great Britain and Ireland." The net of *Nephila plumipes* † consists wholly and invariably of a series of *looped* viscid lines, laid upon radii which gradually increase in length from the upper to the lower region of the net so that the "centre of radiation" is very much nearer the upper than the lower margin, and is, in fact, more nearly in the upper of the two *foci* of the elliptical net; the radii are very numerous and closely set; secondary radii are placed in the wider intervals commencing at various distances from the centre; and the primary dry line is looped like the viscid line, and is *retained;* the necessity for this extra support being evident from the great size of the nets, which range from one to four feet in diameter, and are strong enough to hold a light straw hat.

The free radii are in the same plane with the others, are always

*American Naturalist, 1868, p. 478.

†As described and figured by me in "How our new Acquaintances Spin," Atlantic Monthly, August, 1866, from which fig. 1 is taken.

in the upper region of the net, and occupy about $\frac{1}{6}$ of its area; they are more irregular than the others, and crossed by irregular lines so as to merge gradually into the outer scaffolding, and are crossed by neither the dry nor the viscid looped lines.

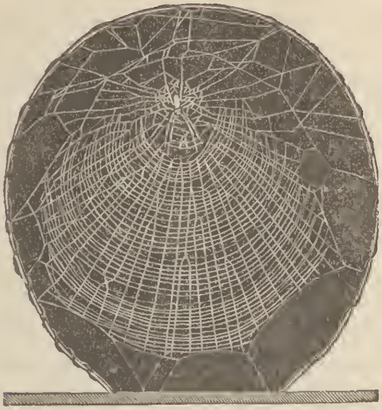


Fig. 1. Net of Nephila plumipes, made in a wire frame, and photographed upon wood; reduced.

In nature, the free radii, as above described, occupy about $\frac{1}{6}$ of the area; but the web of which a figure is given was made upon a wire frame; the limits of which seem to have interfered with the extension of the loops above the level of the centre of radiation.

Hyptiotes (of Ithaca, N. Y.).—The spider, whose web will now be described, no doubt belongs to the genus *Hyptiotes* Walck. (afterward and more generally called *Mithras*); of which there have been described at least two species, *H. paradoxus* and *H. flavidus*, from Europe, the former having been lately found in Great Britain.*

I refrain from giving a specific name, because if there prove to be only one species in the limited states, we may have to retain the name *cavata* which Hentz applied to the species found by him in Alabama, and to which he gave a new generic name *Cyllopodia;*† Hentz, however, states decidedly that it has but *six* eyes (whereas

* It is my intention to publish shortly a full description of the spider, with references to the synonymy kindly furnished me by Messrs. Blackwall and Cambridge of England, and Wm. Holden of Marietta, Ohio.

† Bost. Journ. of Nat. Ant. 1847, vol. v, p. 466.

my specimens have eight), and his descriptions, both generic and specific, are hardly full enough for identification : he knew nothing of the net. Mr. Emerton has a few specimens of both sexes, taken in Massachusetts, which I have not yet examined critically, but I have not heard of its discovery in other parts of the country.

I have not been able to find specimens of *Hyptiotes* earlier than the middle of September, and they seem to disappear about the middle of November; I have never seen young specimens, but certain little cocoons are very numerous in the same localities, so I suspect them to be made by them.

These cocoons sometimes contain about a dozen egg-shells; in which case the spiders have evidently escaped by pushing up the base of one of the guy lines, which seems fitted like a trap door; sometimes the cocoon is empty, and then the outlet is a ragged hole at one side; and in one I found remains of some winged insect, dipterous or hymenopterous, evidently a parasite as with the *Epeira riparia* (see preceding paper), which may account for the ragged holes in the other specimens.

In some cocoons there are eggs as yet unhatched, and I may succeed in rearing the young.

The cocoons are about ·002, in diameter; and those which contain entire eggs include also some loose silk.

It will be seen that the habits of *Hyptiotes*, and the form of its net, with its mode of construction, are sufficiently peculiar to obviate any danger of confounding it with other genera; I have not yet seen the work of Ausserer in which Mr. Holden thinks the net of the European species is referred to, and do not think any extract from it has appeared in this country, so that a full description of the net may not be out of place.

Specimens of *Hyptiotes* were first found by me in the woods bordering Cascadilla Creek in Ithaca, N. Y., in the latter part of September, 1870;* their dull color, their small size (about ·003,5 in length) and their habits of remaining fixed against the hemlock twig, to which the net is attached, may account for their having escaped observation during the two previous years when I collected in that locality.

This species seems usually to construct its net just before daybreak, and I have only twice observed the process; on the 4th of

* Of about fifty specimens then taken, all proved to be females, nor did I find any males until the 28th of Sept. 1873; these are smaller and fewer in number and make no net, being generally found near that of some female. In this as in previous papers I have added notes since the time of presentation.

October, 1870, I saw the last cross-line (that nearest the apex) finished, and four years later, Sept. 28, 1873, I witnessed the formations of the fine lesser lines: as the process was identical in the two cases, there seems good reason to regard it as normal. Some account of this and of the habits of the spider was given at a meeting of the Cornell Univ. Nat. Hist. Soc., for Oct. 10, 1870, when also specimens of the female were shown. The male was exhibited on the 10th of Oct., 1873, at a meeting of the same society.

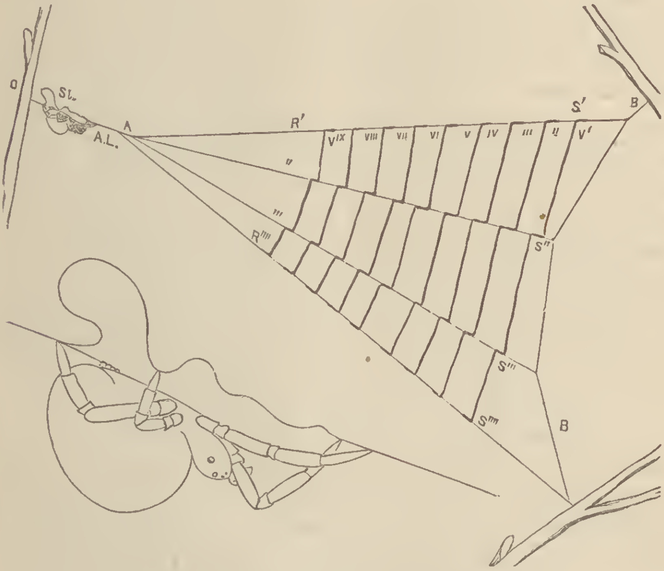


Fig. 2. Net of Hyptiotes "upon the stretch."

BB, base line. A, apex.
O, origin of apex line. R' '' ''' '''' the four radii.
A. L., apex line. V' '' ''' etc., viscid lines.
S' '' ''' '''' Points of attachment of the viscid lines upon the radii; forming little steps upon the latter.
Sl. Slack-line between the first and fourth legs.

This is better shown in the enlarged lower figure, where only the legs of the right side are represented. In the upper figure the spider is shown rather large and the net rather small; the base-line should also be more extended before attaching to the branch at either end.

The net is triangular in form, and consists of four radii, never more or fewer, crossed by several (6 to 10) *independent* viscid lines; the centre of radiation is prolonged into a single nearly horizontal strong and short line which is attached to a branch or twig; the outer ends of the radii are attached to a second strong line more or less nearly vertical and nearly at right angles with the first.

The radii and base line probably involve no unusual process; but the entire independence of the viscid lines contrasts strongly with the spiral or looped lines of *Epeira* and *Nephila*.

At the time of the second observation above mentioned, the spider had completed the base line, B. B., the four radii ($R' '' ''' ''''$), and the four viscid lines nearest the base $V' '' '''$ iv), she was just then passing along the upper radius (R′) from the direction of the apex (A); having reached the viscid line (iv) last completed it turned about, seemed to make some rough measurements of distance with its body, and then, by drawing its spinners along the radius for a short distance (about .002,) formed thereon the same kind of attachment of a new line which I have described and figured in the net of Nephila, and which, though not alluded to by authors, is perhaps generally adopted as much more secure than contact at a single point. The spider then allowed her abdomen to fall away from the radius, hanging therefrom by the first and second pair of legs, and braced away from it by the third pair, she began to move the fourth pair *simultaneously* to and from the mammulæ, so as to extract therefrom a very viscid and elastic line which had a faint yellowish tinge; doing this, she at the same time moved slowly toward the apex, to a point where the interradial spaces were narrow enough to permit her to cross to the second; this she did, ceasing at the same time to draw out the line, which, as she now returned toward the fourth viscid line, contracted considerably, so that it was nearly of the proper length when she attached it to the second radius at a point about as far from the fourth viscid line, as it had been begun upon the first radius; again turning and making the extended attachment as before she repeated the drawing process so as to carry the viscid line to the third radius, and from this to the fourth.

She then ceased drawing the line, and returned to the first radius by way of the crossing (C), began a sixth viscid line, and afterward a seventh, eighth and ninth, all in the same way and at about the same distances apart.

The rapidity of movement of the fourth pair of feet is very great; by considerable effort I could move one hand at about the same rate, and found it to average, *at least*, five times in a second, or three hundred in a minute; about ten minutes were required to complete these five viscid lines, the time spent in returning being very short; and as the other four and longer lines must have taken at least fifteen minutes, our spider may be estimated to move her hind legs definitely and nearly without cessation about 7500 times in less than half an hour; an estimate which is certainly far within the facts.

I have not yet satisfied myself respecting the exact nature of this viscid line,* beyond the exceeding viscidity and elasticity already alluded to; but I do not think that it is "curled" like that of the *Ciniflonidæ*, as described by Blackwall (*op. cit.*, p. 139), and figured by Miss Stavely (*op. cit.*, p. 114).

[For the rest of the description the present tense is applicable, since it applies to the often witnessed proceedings of many different individuals.]

As soon as the net is completed, the spider takes her position on the apex line (A L) at about an inch from the point of attachment (O) with her head toward the net; seizing the line between the first and second pair of feet, she walks slowly backward, "foot over foot", with the fourth pair, until she reaches the point of attachment (O); into which, or into the line near it, she fixes the fourth pair of feet; this proceeding puts the whole net upon the stretch, draws the second and third radii toward the apex, and thus alters the direction of the base line; the slack line (Sl.), which has now accumulated between the points upon the line grasped by the first and second, and the fourth pair of feet, is held away from the body by the third pair, as seen in the lower figure (only the legs of the right side are shown).

I have not yet measured the strain put upon the net, but it is evidently considerable, yet these spiders remain immovable for hours, like a set spring; so motionless are they, and so compactly placed are the legs, that they look more like projections of the wood than living creatures, and no insect would ever mistrust danger from them. But when the web is struck by an insect, the spider shows that though quiet she is watchful; loosing her fourth feet, the strain is relaxed and the whole net regains its original condition with a sharp snap, which causes the elastic

*An account of this and of the parts concerned in its production will be given hereafter.

lines to vibrate in all directions and generally entangles two or more of them upon the insect; should this first attempt fail, the spider, which has been carried sharply forward with the line, but which has retained her equilibrium by means of the third pair, again walks backward and again lets go; this is sometimes repeated six times in quick succession; when satisfied that her prey is entangled, she advances a few steps at a time, apparently feeling her way (as do the Epeiridæ generally), and approaches the quarry by the nearest radius; the subsequent operations are essentially those of the Epeiridæ, and need not be here described; but in some cases, while advancing toward the prey, she cuts the line with her jaws between her front and hind legs, which allows the net to collapse somewhat; the spider, however, has attached a new line in her rear, so that the continuity is not wholly broken; by repeating this, and cutting all the radii, she is enabled at last to gather the entire net within her front legs and to throw it, like a blanket, upon the struggling prey, which is thereby hopelessly entangled; in such cases, therefore, and, in fact, generally, an entire net is destroyed in making a single capture.

Farther account of its habits would be here out of place, but there are some points to be noted in respect to the plan of the net and the mode of its formation.

1. Unlike both *Epeira* and *Nephila* the number of radii is *constant;* in the hundred or more nets which I have examined, there have been always four radii.

2. But the distances between them, the number of viscid lines and their intervals, like the several dimensions of the net, vary considerably, as shown by the following table.

TABLE OF DIMENSIONS OF THE NET OF HYPTIOTES IN MILLIMETERS; TAKEN FROM TEN NETS.

	Length of apex line (excluding slack).	Length of net from apex to base line.	Width of net at longest viscid line.	Length of space included by viscid line.	Number of viscid lines.
Maximum.....	.150,	.210,	.180,	.150,	12
Mean..........	.035,	.150,	.110,	.110,	10
Minimum......	.010,	.100,	.140,	.075,	7

In fact, the net of the spider, like the cell of the bee, as demonstrated by Wyman, is never the model of geometrical precision which we have been led to believe by superficial examination. I have never yet seen the net of any spider in which the eye alone, unaided by instruments, could not discover irregularities, which, if they existed upon a like scale in human workmanship, would be regarded as serious imperfections. But when it is remembered that insects measure spaces in much the same way that we do, by the eye or the limbs, the only wonder is that metaphysicians and theologians ever ascribed to their work an exactness which men attain only through exceeding care and delicate mensuration.

3. Like the nets of *Epeira* and *Nephila*, and probably all others, the net of Hyptiotes is not vertical but inclined at an angle which varies greatly but is generally more than 45°.

4. So too, the inclination of the longitudinal axis of the net varies greatly. I have never seen the apex-line inclined upward from its origin, but have occasionally seen it slope downward at about 45° ; usually the angle is between this and the horizontal.

5. The *independence* of the viscid lines is very striking, but it is evident that the "drawing out" method of this spider would not permit the formation of viscid lines from below upward, without risk of entanglement.

6. The "drawing-out" may impart to the viscid line an elasticity which enables it to shrink to the proper length, after having been long enough to enable the spider to pass from one radius to the next near the apex; it being forced to do this on account of its small size as compared with the interradial spaces; the alternatives would be either—1. To make a larger number of radii, which, however, would increase the resistance to the strain, and lessen the vibrations of the viscid lines: 2. To spin a series of *primary cross-lines*, not viscid, equal in number to the secondary viscid lines, and to use the former as means of crossing while spinning the latter in the ordinary way, then cutting them away as described by some *Epeiridæ;* at present we may hardly conjecture the causes which led to the exclusion of these hypothetical methods, but meanwhile it is to be noted :—

7. That the series of viscid lines must be commenced at the larger and concluded at the smaller extreme, because otherwise either—1. Each succeeding line would have to be engineered by its predecessor which would be between it and the crossing: or,

2. If the spider chose to effect her crossing at the base line, then the shorter lines would have to be carried and stretched the greater distance, and *vice versa;* whereas now, that distance decreases with the length of the viscid lines themselves.

8. The net is *triangular*, the section of a circle, unlike that of any other genus; and, in *idea* at least, may be regarded as filling the vacant space in the net of *Nephila* as compared to that of *Epeira;* so that we may say in mathematical language, *Nephila*+*Hyptiotes*=*Epeira;* in more homely phrase the net *Epeira* is a whole pie, that of Nephila is a pie lacking one-sixth, while that of Hyptiotes supplies the missing piece.

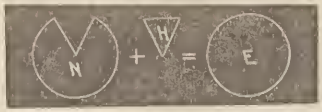


Fig. 2. Diagram representing the forms of nets of *Nephila N.*, *Hyptiotes H.*, and *Epeira E.*

Zoological relations.—The above comparison of the net-patterns of *Epeira*, *Nephila* and *Hyptiotes* is suggestive, but by no means conclusive; and we need to know much more concerning all of them, especially their embryology, before venturing an opinion respecting their zoological relations: particularly since our highest authority is now inclined to place Hyptiotes among the *Cinflionidæ* (Blackwall Ann. and Mag. of Nat. Hist. 1864, p. 436).

It is worth noting, however, that the gap between the continuous spiral net of *Epeira* and the returning loops of *Nephila* may be regarded as lessened by the following considerations.

1. Mr. Blackwall states that *E. calophylla* "usually employs a radius as a means of communication between its net and a small tubular cell of white silk which constitutes its retreat;" . . . and on reaching this radius it retraces its steps until it reaches a point on the opposite side of the radius, and by repetition of this the net is made to consist of a series of *looped-lines*, "arcs of circles:" it does not appear that this "free radius" is always in the same region of the net, although it is probably one of the upper series, as seen in the figure by Miss Stavely (British spiders, p. 246).

2. In several nets of a small species which is common in Ithaca, N. Y., I have (Sept. 28, 1873) seen the addition of four *looped* lines (like those of *Nephila*) to the lower border of the net; and in May, 1871, I found a deserted net built in an angle which

consisted of fourteen turns of the spiral line which formed the limit of the net upon the side toward a fence post, but on the other three sides (the top, the bottom, and the right side), the net was extended by ten looped lines: this augmentation of the lower region of the net would leave the centre of radiation above the geometrical centre, as Emerton states to be the case (Am. Nat., II, 478) with *E. vulgaris*, but without explaining whether it is due to the addition of independent lines or of loops or the increase of the spaces between the spiral lines.

Now since all these spiders hang from the lower surface of the inclined net, and always *head downward*, it is evident that, for the larger ones especially, it must be very much easier to reach even a distant point below their level, or even at one side, than to turn and ascend; and if it shall prove, upon closer scrutiny than has yet been given, that the true *Epeiridæ* may, upon occasion, and under any circumstances, construct a part of their nets of looped lines, it might be conjectured that a habit thus formed would become confirmed, intensified and transmissible; *Nephila* might in this way be regarded as a derivative from *Epeira*.*

The simple triangular net of *Hyptiotes*, with its uniform number of radii and small number of cross lines, might be regarded perhaps as a further specialization from that of *Nephila*, the circle of the *Epeira* being now reduced from five-sixths to one-sixth of its area, and the dry space above the centre in the net of *Nephila*, represented by a single radius, the apex line; but in some respects it is easier to compare the net of Hyptiotes with that of *Epeira calophylla;* the apex line would then represent the single free radius. The ordinary *Epeiridæ*, as well as *Nephila*, are accustomed to vibrate their nets, when touched by insects, and this habit may be the basis of the remarkable method by which Hyptiotes entangles its prey.

Repair of nets.—It is known that the *Epeiridæ* renew the entire net occasionally, and they have been seen to chew it, for the purpose, apparently, of extracting the gum. In most cases, the *Nephila* renews only *one-half* of its net, which varies from one to

* A comparison of their forms looks the same way; for the young *Nephila* is round bodied like the *Theridion*, and makes at first a similarly irregular net of lines crossing in all directions; later it passes through the more elongated form of the ordinary *Epeira* and finally attains the almost cylindrical outline proper to its genus. See previous paper.

three feet in diameter; it cuts the net in two vertically, and stuffs the mingled silk, gum and dust between its jaws, chewing it for several hours, and finally rejecting a black and very hard pellet which seems to consist almost entirely of dust; the half of the net thus destroyed is then renewed by looped lines *necessarily;* the next day, the other half may be renewed in like manner.

It would appear that most *Epeiridæ* renew the entire net at once; but it will be worth while to notice whether the larger species do not, like Nephila, renew only one-half at a time, for if so, they must employ looped lines instead of a continuous spiral.

As stated above, the entire net of *Hyptiotes* is usually destroyed in the capture of a single insect; and as the rejected pellet is quite dry, we may infer that the spider appropriates the viscid portion of the net enveloping the prey.

I shall probably propose the name *Americanus* for this spieies of *Hyptiotes;* for although this may be the species referred to by Hents as *Cyllopodia cavata*, yet his description and figure are insufficient for identification.

The Need of a Uniform Position for Anatomical Figures. By Burt G. Wilder, of Ithaca, N. Y.

The convenience of a uniform position for anatomical figures is sufficiently evident to all; and the neglect of such uniformity is a source of delay and even misinformation to beginners. The position with head to the left is advocated partly because it is more natural, in dissection and drawing; partly because the only author, Professor Agassiz, whose figures are uniformly placed, many years ago chose that position, as may be seen in the "Poissons fossiles." The figures in Huxley's and in Owen's Comparative Anatomy of Vertebrates are often scarcely intelligible, on account of reversed positions, and the larger number of authors seem to regard the matter as of no importance whatever.

Lateral Position of the Vent in Amphioxus and in the Larvæ of Rana Pipiens. By Burt G. Wilder, of Ithaca, N. Y.

The posterior opening of the alimentary canal in *Amphioxus lanceolatus* has been so variously described and figured that a brief historical sketch is here given.*

Historical sketch.—It does not appear that Pallas or Costa or Yarrell remarked any peculiarity in the cloacal region, and I have not seen the earlier papers by Retzius and Müller. Couch (4 (1838) 382) merely states that "the vent is at the length of one-third of the body from the tail," but as in all my specimens the

*The following list probably includes all the important original papers upon this genus; in the text they will be referred to by their numbers as here arranged; the last number will indicate the *page* and the middle one, when it occurs, the *volume*; the list of general works in which Amphioxus is mentioned occurs upon page 278.

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2. Costa, Annuario zoologico, 1834.
3. Yarrell, History of British Fishes, 1836, p. 468 (2nd ed. ii, p. 618, 3rd ed. i, p. 1.)
4. Couch, Mag. of Nat. Hist. 1838, p. 381.
5. Couch, Fishes of Brit. Islands, p. 415, pl. 248. (date ?).
6. Costa, Fauna del regno di Napoli, 1839.
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8. Rathke, Bemerkungen über den Bau des *a. l.*, 1841.
9. Sundevall and Löven, Forhandl. Skand. Naturf. 2nd möde, Kjöbenh. 1841, p. 280.
10. Goodsir, Trans. Roy. Soc. Edinburg, xv, p. 1 and Ann. of Nat. Hist. vii, 346, 1841: also Anatomical Memoirs, vol. 1.
11. Müller, Ueber den Bau und die Lebenserscheinungen des *a. l.* Abhandl. Ak. Wiss. Berlin, 1842, pp. 79–116, Taf. 1–5.
12. Kölliker, Ueber das Geruchsorgan von *A.* Archiv für Anat. 1843, pp. 32-35, Taf. 11, Fig. 5.
13. Quatrefages, Comptes rendus xxi, p. 519, 1845.
14. Quatrefages, Sur l' *Amphioxus*, Ann. des Sciences Nat. 1845, pp. 197-248, Pl. x–xiii.
15. Gray, *A. belcheri*, Proc. Zool. Soc. 1847, p. 35.
16. Müller, Monats. Akad. Wissen. Berlin 1851, p. 474.
17. Sundevall *(Branchiostoma elongatum)* Oefuers, Vet. Ak. Förhandl. 1852, p. 147.
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19. Max Schultze, Verhandl. Naturhist. Vereins preuss. Rheinl., xix. Sitzungsber. p. 197. Also in Siebold's and Kolliker's Zeitschrift iv, 1852, p. 416, taf. 13, figs. 5 and 6.
20. Kroyer, Danm. Fisk, iii, p. 1,087 (date ?).
21. Steenstrup, Oefuers. Dansk. vid. Selsk. Förhandl. (1863) 1864, p. 238.
22. Marcusen, J., Comptes rendus, 1864, pp. 479–483. Also in Ann. and Mag. of N. H., 1864, xiv, pp. 151 and 319. Also in Rev. et Mag. Zool. 1864, xvi, p. 79.
23. Kowalewsky, Mem. Ac. Sc. St. Petersb., 1867, xi, No. iv, pp. 16, 3 pl. abstract of same in Bibl. Univ. Art. 25, 1866, Bull. Sci. pp. 193–195, transl. in Ann. and Mag. of Nat. Hist. 1867, p. 69.
24. Bert, Comptes Rendu 1867, p. 364 or Ann. and Mag. of N. H., xx, p. 302.
25. Owsjannikow, Bull. de la Ac. Impe. des Sci. de St. Petersb., tome xiii, No. 4. pp. 287–302, 1868.
26. Moreau, Obs. sur la struct. de la corde dors. Comptes rendus, May, 1870, p. 1006.
27. Moreau, Note sur la région cranienne, Comptes rendus, May, 1870, p. 1189.

post ventic region forms only $\frac{1}{7}$ or $\frac{1}{8}$ of the whole length, Couch probably referred to the "abdominal pore." It is worthy of note, however, that Couch's figure, though rude and in some respects inaccurate, rightly indicates the fact, apparently overlooked by all other observers before and since, that the ventral border of the left muscular mass retreats a little at the cloacal region (as shown in my figures) so as to expose the mesial surface of the right muscular mass or the cloaca itself when distended.

Goodsir (10 (1841) 382) says "The anus is in the form of a longitudinal slit," as appears also in all his figures, one of which is reproduced herewith (Fig. 1. G). These figures have the location of the vent nearly correct in proportion to the length of the body, but the author states that the "anal fin is interrupted at the anus," 375, whereas it is usually, if not always, widest at that point. It must be remembered, however, that Goodsir's observations were confined to *two individuals*, and his dissections to but *one* of these, and while correcting his errors, we are more inclined to wonder at the amount of new information which he obtained from so scanty material.

Fig. 1. G. Hinder part of *Amphioxus*, from below; copied from Goodsir, Pl. 1. Fig. 4.
M. The same, from the left side; copied from Müller, 11. Taf. 1. Fig. 1.
Q. The same, from the left side; copied from Quatrefages, Pl. xiii, Fig. 1.

From his second paper (11, 1842) it appears that Müller had plenty of material; he rightly locates the vent opposite the broad part of the caudal fin (as seen in Fig. 1, M) making the intestine project slightly as a narrow tube with oval orifice; his description is as follows (translated): "The vent lies on the left side of the abdominal fin; this anomalous position of the vent upon one side of the anal fin recalls a similar peculiarity with *Lepidosiren*;"* both figure and description show therefore that Müller supposed the vent of Amphioxus to differ from that of most vertebrates, merely in its lateral position, and no allusion is made to the peculiarity in the concluding general remarks.

* It will be seen hereafter that in this genus the condition of things is quite unlike that in *Amphioxus*.

In the somewhat extended paper of Quatrefages (14) it is not easy to separate his own observations from his summary of preceding ones; as seen in Fig. 1, Q, the vent is the oval orifice of a simple tube which opens far in advance of the expanded caudal fin, which also is shown rather shorter than is natural; as in Müller's figure, however, the vent is correctly shown to the left of the "abdominal segmented canal."

Quatrefages' description (translated) is as follows: "The anus lies at a point where the membranous border enlarges into a lancet form, it opens upon the left side of the abdominal surface of the body, close to (*tout auprès*) a membrane which occupies the median line." p. 201.

Later observers seem to have overlooked the "anomalous location of the vent," referred to by Müller and Quatrefages.

The formation of the anus, by a gradual constriction of the borders of the "secondary cavity" is described by Kowalewsky (23, pages 3, 4, 5, 7); the figures of the earlier stages indicate that the anus is median; some of the later ones show it as if on the left and others as if on the right side; but the text nowhere refers to any unsymmetrical position, which is the more noteworthy because attention is called (10) to the unsymmetrical character of the *oral* aperture.

We may conclude that our author, while no doubt well aware of the general opinion respecting the vent of the adult, did not under-

Fig. 2. (copied from Kowalewsky. Entwick. des *Amphioxus*; the caudal region of the embryos shown in Fig. 22, 23 and 28, corresponding to A, B and C, respectively.

A. An embryo of sixteen hours, seen from above, showing the outline of the intestine which narrows and opens at the anus *a* apparently upon the *dorsal* region of the body, with a single series of ciliated epithelial cells behind it.

The letters R and L are added better to designate the relative position of parts.

B. An embryo of twenty-four hours, seen from the *right*; a, the anus which appears to open on the right side of the body.

C. An older embryo seen from the *left*, on which side the anus appears to open; and this is the more confusing from the considerable backward extension of the caudal region.

No reference is made in the text to the exact position of the orifice.

take to elucidate the manner in which this condition was reached; although, had he so chosen, his opportunities and the skill elsewhere displayed, would have enabled him to clear up the obscurity which now rests upon it.

Most systematic works and zoological text-books* published since the discovery of *Amphioxus* include more or less complete accounts of its structure; but as their authors have not published separate papers upon the subject, one can only conjecture the extent of originality in their descriptions.

The recent and very complete work of Claus (51) states that the "vent is somewhat laterally placed;" and further (p. 830) that the development (according to Kowalewsky) involves "striking asymmetry with respect to the mouth, vent," etc.

Schmarda (52, 302, fig. 501) gives a somewhat altered copy of the figure from Quatrefages, but no reference to the vent.

Huxley (55, p. 117) says that the "anal aperture is a little to the *left* of the median line," yet his figure, apparently copied from Müller, is *reversed* so as to bring the vent upon the *right* of the anal fin.

Troschel (59, 284) says that "the fin passes to the right of the vent."

Owen (56, 1, 31, fig. 23) gives a purely diagrammatic figure of the organs of *Amphioxus*, in which the intestine opens on the median line, and the text contains no allusion to a peculiarity in that region.

Clark (60, fig. 226) copies Owen's diagram without comment; and Gegenbauer (53, 788), in like manner, copies Quatrefages, merely saying (p. 799), "Die Cloaken bildung fehlt bei *Amphioxus*."

Hæckel offers a figure (61, Taf. xiii), which mainly resembles

* SYSTEMATIC WORKS (arranged in no special order).

51. Claus, Grundzuge der Zoologie, 1872, 828.
52. Schmarda, Zoologie, 302, fig. 501.
53. Gegenbauer, Vergl. Anat., 1870, 778, fig. 256.
54. Rolleston, Forms of Animal Life, 1870, lxxxiv.
55. Huxley, Anat. of vert. animals, 1871, 116, figs. 28 and 29.
56. Owen, Comp. Anat. and Phys. of Vert. 1, 31, fig. 23.
57. Agassiz and Gould, Principles of Zoology, 1848, 181, fig. 153. (Shows correctly the position of vent.)
58. Vander Hœven, Hand book of Zoology, 56, 1858.
59. Troschel, Handbuch der Zoologie, 1871.
60. Clark, H. J., Mind in Nature, 1865.
61. Hæckel, Natürliche Schöpfungsgeschite, 1872.
62. Gunther, Catalogue of Fishes in the British Museum, vol. viii.

that of Quatrefages; and Gunther (62, 513) enumerates, among the generic characters, "a low rayless fin runs past the vent;" so far as I know the point is not alluded to by other systematic writers.

It appears therefore that to many the lateral position of a normally median primary opening seems to require no mention, and that when the asymmetry is alluded to, it is not certain whether the vent is lateral and the fin median, or the reverse.

The reception of a large number (about one hundred and fifty) of specimens, well preserved in spirit,* and the subsequent opportunity of examining sixty specimens from the coast of Florida, belonging to the Museum of Comparative Zoology,† have enabled me to investigate this point quite fully.

Nothing of the exact structure of the vent‡ can be made out with the naked eye; in addition to the dissection of many individuals under the lens, I have made about two hundred microscopic sections of the cloacal region; and the following account is based upon their careful and prolonged comparison.

It would be more amusing than instructive to enumerate the many and different opinions successively formed in the course of this investigation before the present conclusion was reached, and while admitting the possibility that the true condition of things is not yet known, I shall ask of the critic to state the amount of material upon which his contrary opinion is based. I am well aware of the insufficiency of both figures and description, especially in respect to the minute anatomy of the tissues; upon some of these points I have nearly made up my mind; but as all of them are more or less involved in the general structure, and some of them are quite differently represented by different authors, it seems

*Collected at Naples and sent by mail by my friend and former student, W. S. Barnard, S. B., Ph. D.

†Just as this paper is going to press, Prof. Putnam has kindly loaned me two specimens from the Florida coast which agree so entirely with the specimens belonging to the Mus. of Comp. Zoology, and are so immediately distinguishable from the Naples specimens, in form and in the proportions of the regions, that I feel almost assured of the specific distinctness of the *Amphioxus* from the two localities; but, as will be explained farther on, no conclusion upon this point can be regarded as reliable unless based upon the accurate measurement of many specimens, and the enumeration of the segments composing their different regions: this will take time, but will be done as soon as possible.

‡The terms *cloaca* and *vent* are here used provisionally; at present, notwithstanding all that is known of the different morphological and physiological relations of the alimentary, urinary and generative outlets in vertebrates, as briefly stated by Huxley, 109, 131, 138, the above terms are not clearly discriminated from *rectum* and *anus*.

better to defer a discussion of them until the completion of the study which I am now making of the entire organization of this lowest, and in most respects, anomalous vertebrate. This paper may be regarded as a preliminary notice of a single part of the subject.

Fig. 3. A. *Amphioxus*; seen from the left, natural size; V, the vent; A P. The abdominal pore.

B, C, D. Transverse sections at middle of body to show different conditions of ventral wall in different individuals.

B. A cross-section of the body at the middle of its length, showing the "abdominal groove."

C. The same of a Florida specimen, in which the abdomen is flat, or but slightly convex.

D. The same of a Naples specimen, full of eggs, in which the abdominal groove is obliterated.

The simplest presentation of the subject will be an explanation of the figures.

Fig. 3 shows an *Amphioxus* (from Naples) of the natural size, head to the left; no details of structure are given, but there is no question respecting the existence of an expanded vertical fin around both ends of the body; the notch V indicates the location of the vent. and the notch AP the location of the abdominal pore.

Most of the Naples' specimens present the abdominal groove described and figured by Müller as formed by two lateral folds of the integument extending from the mouth to the abdominal pore (Fig. 3, B); * a specimen sent from Naples by Prof. Panciri to the Museum of Comparative Zoology is distended by the enlarged reproductive organs, and these folds are *wholly obliterated*, together with of course, the groove (Fig. 3, D); and most of the Florida specimens (taken in May), in which the reproductive organs are less bulky, have loose ventral parietes, as if regaining the grooved condition during the gradual discharge of the reproductive products (Fig. 3, C); so it is quite possible that the folds and grooves are periodical appearances for the accommodation of the reproductive development.

Position of the Vent.—The position of the vent with respect to the fin and length of entire body is very differently represented

* A similar groove exists in the male pipe-fish (*Syngnathus*) but is located *behind the vent*.

by Müller and Quatrefages; in all my Naples specimens the vent is as in Müller's figure opposite that part of the fin which first gains its greatest depth, passing from before backward or just before it begins to decrease in depth, passing from behind forward.*

In one of the larger specimens from Naples .045, in length (about two inches) the vent is .005, from the tip of the tail, and the abdominal pore .009, in front of it, or .014, from the tip; the latter opening is therefore about one-third of the length from the tip and the former one-ninth. Or, assuming the length of the body to be 100, the post poral region is .31 and the post cloacal region .11.

Müller's figure yields the following ratio, post poral region .13, post cloacal region 4, while according to Quatrefages' figure the post poral region is .41 and the post cloacal .23. But as one of the Florida specimens, .043 in length, gives the same regions as .25 and .9 respectively, we may infer the existence of considerable variation. It is my intention to present a large series of accurate measurements of specimens from various localities as one element in the determination of specific or variety differences.

TABLE OF PROPORTIONS OF AMPHIOXUS, AS DERIVED FROM SPECIMENS FROM NAPLES AND FLORIDA, AND FROM THE FIGURES OF MÜLLER AND QUATREFAGES (IN MILLIMETERS).

	Total length.	From vent to tip of tail.	Ratio to whole length.	From abdom. pore to tip of tail.	Ratio to whole length.
Naples....	.045,	.005,	.11	.009	,31
Florida.................	.043,		.09		,25
Müller..................			.04		,13
Quatrefages............			.23		,41

THE VENT AND THE FIN.—Leaving out of view for the present the absolute position of the vent with respect to the median line,

* In many alcoholic specimens, especially those from Naples, the fin is carried to the left and as it were wrapped over the entire cloacal region (as indicated in the Fig. 6 C) and this in connection with the peculiarly protected orifice of the vent, the sharpness of the tail, and the suspected existence of a caudal sense organ suggests the possibility of occasional retrograde locomotion.

it is desirable to confirm the general opinion that it lies to the *left* of the *abdominal* (*caudal or anal*) *fin*.

I first selected, at random, fifty specimens from the Naples lot, and carefully introduced a black bristle into the vent. The naked eye can hardly detect a difference between the two sides of the cloacal region, but the bristle would never enter the right side, while, by a little preliminary movement to the right (the necessity for which will appear farther on), it readily entered upon the left side of the fin.*

Forty more of the same lot were examined in other ways either by section or dissection, with the same result. All of the sixty Florida specimens were afterwards examined, and the vent found to open always upon the *left* of the fin.†

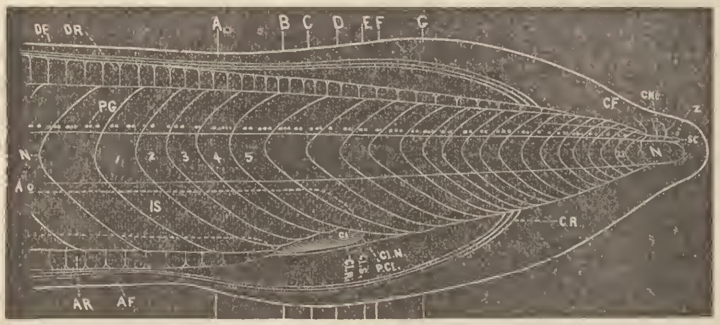

Fig. 4. Hinder extremity of *Amphioxus*, magnified about ten diameters. (For fuller explanation, see the text and the explanation of the lettering upon the next page.)

We may fairly conclude from these one hundred and fifty specimens, that in the *Amphioxus* of the Mediterranean and of the Florida coast, the vent opens to the left of the abdominal fin; and that exceptions will probably be as few as are the cases of transposition of viscera with men, and not to be compared with the exceptions to the rules as to "blind sides" among *Pleuronectidæ*.

*In order to avoid some errors into which I was led, I would add that specimens so treated, however carefully, are not fitted for sections or for minute examination of the cloacal region; the cloacal valve is apt to be ruptured or distorted, and the pressure of the bristle unnaturally prolongs the cloacal notch.

† These specimens are less well preserved than the others, and either from this cause, or from a difference in the natural width of the body (into which I shall inquire with a view to possible specific difference), it is easier to see the parts with the naked eye or a feeble lens.

The following explanation of the lettering applies to all the figures of *Amphioxus*.

Ao — Aorta.
AC — Abdominal cavity.
AF — Abd. fin (anterior to caudal expansion).
AFo — Abd. folds.
AG — Abd. groove.
AL — Abd. lamina (lateral).
AMS — Abd. median septum.
AR — Abd. ridge.
AS — Abd. segmented canal.
AP — Abd. pore.
B — Basement membrane.
Cl — Cloaca.
ClR — Cloacal ridge.
ClN — Cloacal notch.
ClS — Cloacal sinus.
ClV — Cloacal valve.
ClA — Cloacal aperture or vent.
CF — Caudal fin.
CR — Caudal fin rays (only *three* shown above and below).
CNe — Caudal nerves.
CC — Central canal of spinal cord.
Ci — Cilia.
DF — Dorsal fin (anterior to caudal expansion).
DR — Dorsal ridge.
DFi — Dorsal (posterior) fissure of spinal cord.
DS — Dorsal segmented canal.
F — Fæces.
HNA — Hyperneural arch.
HNC — Hyperneural canal.
I — Intestine.
IC — Inner (mucous ?) coat of intestine.
IS — Intermuscular septum.
ICC — Inner (mucous ?) coat cells.
M — Mesentery.
MC — Middle (muscular ?) coat of intestine.
My — Muscular mass.
N — Notochord (the thick wall of the tube).
NS — Notochordal sheath (of connective tissue).
NL — Notochordal laminae (contents).
NA — Neural arch.
NC — Neural canal.
Nu — Nucleus.
P — Peritoneum, lining abd. cavity and covering intestine.
PG — Pigment granules of cord.
PC — Posterior aspect of cloaca.
SC — Spinal cord.
SM — Sphincter muscle of cloacal valve.
T — Integument.
TC — Tegumentary cells.
V — Vent or cloacal aperture.
Z — Supposed caudal sense organ.

1, 2, 3, 4, 5, etc. Caudal myocommata or muscular segments beginning with that which first abuts upon the cloaca.

Fig. 4 represents the caudal region magnified about ten diameters; it is in part diagrammatic, so as to include more features than could be really seen upon a single specimen without dissection. The Notochord (NN) is shown in its whole length, tapering gradually backward. Only the hinder end of the spinal cord (SC) is shown, but its course is indicated by the pigment granules (PG); which form a double row upon the sides of the median line throughout the whole length of the body excepting near the head (as shown by Müller and Owsjannikow) and near the posterior extremity; none of my specimens show them beyond the point where the muscular segments seem to cease, mainly about .000,5 from the tip of the cord; as shown by Owsjannikow, the granules are not generally opposite each other, or at regular intervals, in my specimens.*

Three spinal nerves are shown (CNe) of which the most anterior

* The cord is shown ending in a simple and free manner but I have several preparations which indicate some connection between its extremity and what appears to be a funnel-shaped canal leading from the surface at the point Z. I shall make this a matter of special investigation hereafter; Quatrefages describes the tip of the cord as enlarged, but is not certain of the constancy of that peculiarity.

The precise histology of this, as of all other parts, can only be determined and illustrated by very numerous preparations in different aspects and by much enlarged figures.

has a ventral as well as a dorsal division. (Compare Quatref., 14, pl. xii, fig. 1).

Excepting in very small specimens, the nerves can be seen only after carefully stripping off the integument, and the same is necessary in order to see the *caudal fin rays* (CFR).

Caudal fin rays.—I am quite sure, from numerous observations upon small specimens from which the skin was removed, that the rays whose cut ends appear upon vertical section of the caudal region arise in a continuous series along the dorsal and ventral borders of the body, at least as far forward as the vent and run forward *almost horizontally.* Several *short* rays are represented by Müller (11, Taf. 1, Fig. 3 and p. 88) rising near the tip of the tail and inclining slightly forward. I am certain that these rays continue uninterrupted, and without branching over several segments; but I have not yet assured myself of their precise distribution, nor in what way they are accommodated in the narrower fin in front of the vent: I venture therefore to show only three rays above and below.

As represented by all authors, the myocommata (muscular segments) incline backward at their dorsal and ventral extremities so as to form a pretty regular curve the greatest convexity of which lies just opposite the notochord; the ventral moiety is the longer (excepting near the tip of the tail) and seems to extend farther back than the dorsal; but there seems to be no secondary dorsal and ventral curve as in ordinary fishes.

But there are dorsal and ventral longitudinal structures, which have been so variously described that, at present, I prefer to designate them merely as the dorsal ridge (DR) and abdominal ridge (AR) and their cavities as dorsal and abdominal segmented canal (DSC and ASC).

Whatever may be the precise nature and functions of this structure, however, it is in direct relation with the root of the fins and will form an element in the question of the position of the fins and the vent in respect to the median line. The dorsal ridge extends backward upon the median line almost to the final myocomma (this is shown in any lateral view, but I have not yet carried sections into that region). The abdominal ridge, in like manner, is median from the abdominal pore (not shown) backward upon the median line, to where the abdominal fin expands into the caudal; here it decreases in size more rapidly than the dorsal ridge does at a corresponding point (although the interspaces are not shorter) and wholly disappears *from the lateral view* at the commencement of the cloacal region (its continuation will be seen in the sections) nor does it appear again in the post cloacal region, contrary to the figures of all authors.

THE CLOACAL REGION.—As first figured by Couch (4. p. 381), though not described and apparently not understood by him, and overlooked by all subsequent observers, the cloacal region is distinctly marked upon the left side by the failure of three or four myocommata to reach the level indicated by the corresponding myocommata of the right side.

In most of the specimens examined by me, the condition of things is represented in Fig. 4.*

The ventral extremity of the myocomma marked (1) is very slender and just fails to gain the level of the myocomma next in front; its successor (2) ceases at a still higher level and the next two (3 and 4) at higher and higher so that their ventral borders form an oblique outline from below, backward and upward; the greatest height of the space so uncovered being about .000,3 from the normal level, or about one-seventh of the depth of the body at that point; this line forms the antero-dorsal boundary of the cloacal region; the corresponding postero-dorsal boundary is formed by the antero-ventral border of the next myocomma (5) which reaches its normal level, as do its successors; the background of this space is formed by the mesial surface of the corresponding right myocommata, and its ventral outline is a pretty definite ridge (ClR), the nature of which will appear upon the sections.

The posterior fourth of the cloacal region is vacant and may be called the cloacal notch (ClN); (it is this which is liable to unnat-

* There is considerable discrepancy in the number of muscular segments (myocommata) both for the whole body and for separate regions; in the specimen figured (Fig. 4) I find that the ventral ends of four segments abut upon the cloaca, the most anterior very slightly, the fifth segment passes the cloaca and forms the dorsal and posterior boundary of the notch and there are sixteen more caudal segments, but in other specimens from Naples and also from Florida, there seem to be no more than fifteen post cloacal segments; there is reason to believe that the number varies with age but it is quite possible that the comparison of a large number from various localities may indicate a constant numerical difference serving to distinguish geographical varieties, and even, perhaps species; there is certainly a considerable difference in the height and thickness of the body, between the specimens from Naples and from Florida.

ural extension backward by the introduction of the bristle, as mentioned on page 282). The remaining three-fourths is usually occupied by the cloaca (Cl) excepting a slight interval between it and the background and ridge, which may be called the cloacal sinus (Cl S).

THE CLOACA.—In most small specimens and many of the larger ones from Naples, all which are strongly contracted by the spirit, the elongated triangular space (cloacal region) above described is empty; but the tegumentary cells may easily be traced over the rounded borders and also upon the deeper level of the background, from the surface of the fin, which is here connected *wholly with the right half of the body.*

But in other of the Naples specimens, and in all of those from the Florida coast, which, so far as this region is concerned, seem to be in a more nearly normal condition, the anterior three-fourths of the space presents a semi-cylindrical elevation of integument with a curved posterior outline. Its surface is continuous *dorsally* with the slightly overhanging margin of the myocommata; *posteriorly* with the contiguous surfaces of the cloacal notch; while the ventral surface is slightly separated from the underlying cloacal ridge, and extends across the middle line as will be shown in Fig. 5. It will be noted that this surface is smooth and presents no orifice whatever, and that we cannot therefore admit that the vent opens toward the left side of the *body;* this however by no means contradicts the statement that it opens to the left of the abdominal fin.

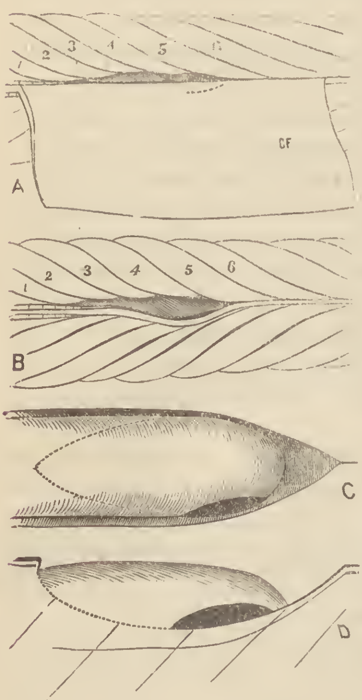

Fig. 5. Diagrammatic views of cloacal region from below (A, B and C) and from right side D; all more or less enlarged.

Fig. 5, A. View of the cloacal region from *below*, and still more enlarged than in Fig. 2. The caudal fin (CF) is turned over toward the right, but not distorted; its base is *upon the median line*, as seen at both ends of the section, and its exposed *border* therefore lies a little to the *left of that line;* the hidden border of course, to the right; upon each side of the anterior section is seen the abdominal ridge (AR) which is soon hidden upon the right, by the deflected fin, but continues backward upon the left to the cloaca where it seems to cease, but, in reality (as seen in B and in Fig. 4), is only narrowed and deflected dextrad of the median line so as to pass the cloacal region; the five cloacal myocommata are numbered 1–5, and the succeeding one 6.

It will be noted that owing to the fact that the base of the caudal fin preserves its true longitudinal course over the cloacal region, a little less than *one-half of the latter is visible;* the curved dotted line indicates the location of the vent; which is really dextrad of the median line, although practically, the outlet or pseudo-vent is a little *sinistrad* of that line, namely around the border of the base of the fin.

Fig. 5, B, is the same as A, excepting that the caudal fin is removed down to its attachment, so as to expose nearly the whole cloacal region; the attachment itself is deflected like the abdominal ridge, but remains visible around and behind the cloaca, where it again comes upon the median line; the cloacal notch is shown as a triangular black spot at the posterior extremity of the cloacal region, and the vent itself as a dark line upon the right posterior border, somewhat oblique, so as to be nearer the median line behind, but *not reaching it.*

In C, the cloacal region is still farther enlarged so as to show the relation of the parts to the median line; the dotted line indicates the limits of the exposed portion of the end of the intestine; the posterior extremity is seen to be rounded and the vent is a valvular aperture.

D shows the same from the right side, and diagrammatically; the border of the valve should be represented as slightly thickened and rounded.

I hope at some future time to give more detailed figures of this region, but these sufficiently indicate the morphological relations.

In figure 6 are given enlarged diagrammatic representations of transverse sections made at seven different points as indicated by the corresponding capital letters upon Fig. 4; all are as viewed from *behind*. As already stated, these figures indicate the results of a careful and prolonged comparison of several hundred sections made upon many specimens between the points A and G.

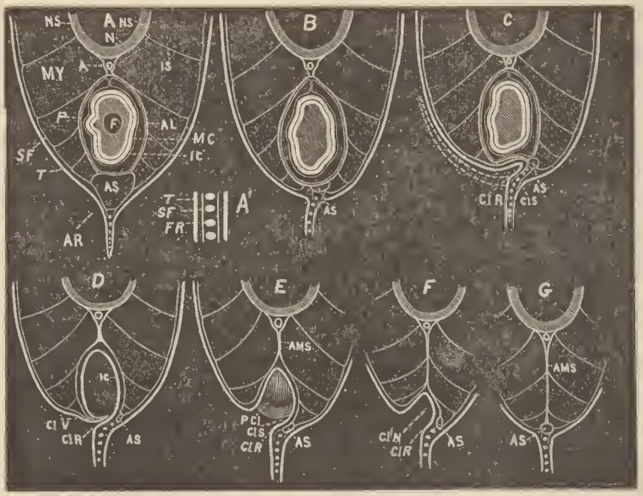

Fig. 6. Sections of cloacal region (ventral half of the body) as seen from behind. A is just in front of the cloaca and G just behind it; the others at intermediate points indicated by the lines in Fig. 4.

A is just in front of the cloacal region and G is just behind it; both of these are, therefore (or should be), symmetrical figures; all the others are more or less asymmetrical on account of the deflection of the abdominal ridge, and the attachment of the fin, and the location of the vent itself upon the right aspect of the cloaca.

The sections of course included the whole animal, but as the present paper concerns only the cloacal region, and several parts of the general anatomy of the dorsal region are in doubt, I prefer to show only what I am pretty certain of.

The lettering is uniform and explained elsewhere (p. 283). The general arrangement is best seen in A. The lower half only of the notochord (N) is shown, and its contents are omitted from doubt of their exact nature; as in *Petromyzon*, etc., the notochord is surrounded by a sheath of connective tissue (N S) from which are given off the various *intermuscular septa* (I S) which separate the *myocommata* (My), and the *abdominal laminæ* (A L) which line the abdominal parietes. The *aorta* (A) lies between two laminæ; below the abdominal cavity the laminæ join the connective tissue walls of the *abdominal segmented canal* (AS) which constitutes the *abdominal ridge;* to the sides of the latter also, are joined the corresponding *subcutaneous fascia* (S F) which envelops the tegumentary surface of the muscular masses; to the lower border of the abdominal segmented canal also are attached the subcutaneous fasciæ of the caudal fin, which are only partly shown in the series A–G, but much enlarged in A′. The fin itself is wholly shown only in A, where its depth is slight; but its relative depth in the other sections may be judged by comparison with Fig. 2, which is magnified only half as many diameters.

In this too are shown the cut ends of the *caudal fin-rays* (C F R), already described; they seem to be usually oval in section, and sometimes composed of two lateral pieces; but their structure must be more minutely investigated.

Within the abdominal cavity is seen the cut end of the intestine, which, at A, contains a fæcal mass F. All authors state that the alimentary canal is ciliated throughout, but give no figures of either the cilia or the cells to which they are attached and leave us to suppose that no muscular or peritoneal coats exist.

As all these are points of minute anatomy which can be best determined upon living or fresh specimens, I hesitate to offer a description or figure of the parts, and must ask that both be regarded as provisional. As might be expected, so delicate a tissue as the peritoneum was rarely left uninjured in a section, but I think it exists in several specimens in the relation which is normal with vertebrates, and which is diagrammatically indicated in the figures (P), of course the parietal and visceral layers are really *in contact* with each other above (forming the mesentery M) and with the connective tissue and alimentary canal elsewhere.

The existence of an inner or mucous or epithelial coat is certain, also that, in the intestinal region, at least, it consists of columnar cells which give a striated aspect to the section; these cells are from .001 to .002 of an inch in length, and seem to be longer in the anterior than in the posterior part of the intestine, giving a corresponding variation in the thickness of the mucous membrane (IC); traces of cilia appear in several of the sections, but I do not feel sufficiently sure of their uniform presence or their character to include them in the figure.

As said above, no muscular coat is assigned to *Amphioxus* by previous describers, nor have I seen any structure answering to it in the anterior part of the intestine, but in its posterior part and especially in the cloacal region, so constant is the appearance of a second coat outside of the mucous coat that I venture to insert it, provisionally, in the figure; very often it is somewhat separated from the mucous coat; its thickness is about the same but its structure is granular and not at all striated; prior to the investigation of this point upon fresh specimens, I would only suggest that perhaps the muscular coat is needed near the cloaca for the periodical expulsion of the fæces which are brought back by the constant action of the cilia, which may possibly exist only in the anterior (branchial) region of the alimentary canal.

B presents nearly the same appearances, but as it is a section just at the anterior angle of the cloacal region, it presents an indentation upon the left side of the base of the caudal fin, while the *abdominal segmented canal* (AS) is deeper in position and thrown to the right of the median line, like the fin attachment.

In C this change is more marked, the section being through the middle of the length of the cloaca, the AS is thrown far to the right and the base or attachment of the fin likewise, but the latter soon regains its normal position upon the median line, giving rise to two important features of this region the *ridge* and the *sinus*.

The *cloacal ridge* (CR) is the sudden angle formed by the vertical and median blade of the fin with its deflected basal part; it forms the outline shown as a single line in fig. 2 and appears in fig. 3 A as the sinister border of the fin.

The *cloacal sinus* (CS) is the space between the sinister surface of the deflected basal part of the fin and the ventral surface of the cloaca itself. The dotted line represents the fin in the condition already alluded to (p. 286) as thrown across and upward upon the left side so as to enclose and protect the cloacal sinus and the already concealed vent.

In D we have a section directly through the vent and exhibiting its peculiar features. As might be inferred from the other figures

(4 and 6 C) the integument may be traced from the left surface of the body upon the ventral surface and across the median line to a point where, in C, it becomes continuous with the integument of the fin-base, but in D it remains distinct and presently returns upon itself so as to form the mucous lining of the cloaca and the inner surface of the *cloacal valve* (ClV) which itself is merely the ventral wall of the cloaca, free upon its right border for the extent of the vent.

I have not represented the muscular and peritoneal coats in this section for I am not quite certain as to their points of commencement; neither a peculiar striated structure which appears in this part of the *valve* and which may be a special muscle for opening or closing the vent.

At E the section is made just behind the cloaca, so as to present its *posterior rounded surface* (PCl) which is continuous with the integument in all directions. The height of the cloacal cavity, which had somewhat decreased in D, is here little more than half what it was in A and the sub-aortic union of the abdominal laminæ here forms an *abdominal median septum* (AMS) the connections of which are as in all excepting A somewhat asymmetrical. The AS is rather larger and nearer the median line; the sinus and ridge occupy their usual places.

At F the section is through the vacant space, or *notch* (ClN) already described in fig. 2 and fig. 3, B, C, D, as a trihedral depression from the left side at the base of the fin; the median septum is still deeper, and the A S C nearer the median line.

In G, we find a return to the symmetrical arrangement of parts, but with the absence of the alimentary canal; the septum is median and its connections regular. In fact, in some respects it is easier to describe and study the sections in the reverse order beginning with G; which presents the simplest structure.

But although the arrangement above described may be required for protection of the cloacal outlet, especially during backward locomotion, yet it is quite possible that in order to avoid such circuitous exit for the fæces, the animal may flex its body strongly ventrad, to such an extent as to allow the deflected basal part of the fin to hang more directly from its attachment, and so expose the true vent at the moment of deflection; this must be determined by observation of living individuals. But this does not affect the morphological position of the vent upon the right of the median line, but to the left of the abdominal fin, whose basal part is here deflected and attached wholly to the right half of the body.

I foresee one possible exception to the above interpretation of the morphological relations of the vent; upon the ground that the abdominal ridge and the fin are *normally median organs* like the similar dorsal structures, it may be urged that since the cloaca lies to the left of them, *it* is lateral in position, and to the left of the median line, and that perhaps the vent itself, if distortion were removed, might perhaps be regarded as median in its position, or nearly so.

This view would be strengthened by reference to the manner in which the *abdominal median septum* (AMS) maintains its connection with the abdominal segmented canal (ASC), as it is traced in the series of sections from G to A.

For a long time, while studying the sections under the microscope, I felt anxious to see that the median septum consisted of two lateral sheets which separated below so as to receive the alimentary canal; but there is no good evidence of this, any more than in the other fishes, where this septum consists of fibres interlaced in all directions, with no reference to a median division; and in F and E the septum seems to be deflected from the median line and to pass wholly to the right, leaving only a branch to go to the left.

But to this must be said—1. That the various septa form a continuous sheet of connective tissue, which is thicker in some places and thinner in others; that naturally the larger part of the median septum would retain its connection with the fin and the abdominal segmented canal which is evidently associated therewith: and, 2. That although the septum, and the abdominal segmented canal and the fin are all normally median organs, yet the latter two are *peripheral parts*, and hardly entitled to serve as criteria for determining the morphical position of a comparatively central or axial canal like the intestine; and although the septum consists of sclerous tissue, and might be ossified, and so become a part of the skeleton, to which all other organs are generally referred for their location, yet it must be remembered that the morphological value of the spinal axis arises not from its being of osseous or sclerous tissue, but from its primary appearance upon the line of the primitive furrow; in like manner the spinal cord and aorta and alimentary canal are all median and primary and permanent organs; and their right to be so considered is not to be denied on account of the appearances presented by accessory prolongations of connective tissue, or by peripheral and transitory organs like the fins.*

RECAPITULATION.—1. The *abdominal folds* and the furrow between them extending from the oral aperture to the *abdominal pore* are periodical appearances, according to the condition of the reproductive organs.

2. The cloaca is usually about one-ninth (or .11) of the total length from the tip of the tail, and, including the four myocommata which abut upon it, there are 20–25 myocommata behind it; both the ratio and the number, however, are probably variable.

3. The caudal fin contains very long and delicate *anteverted* fin rays.

4. The caudal fin is continuous with the dorsal and abdominal fins; and the cloaca lies opposite the point where the greatest depth of the fin is acquired, passing from before backward.

5. On the left side three or four myocommata fail to reach the general level of the ventral border of the body and so expose the cloaca.

6. The *dorsal ridge* is always median and is visible to near the tip of the tail; but the abdominal ridge is deflected to the right of the cloaca, and does not reappear behind it, although it regains the median line.

7. The abdominal fin likewise loses its connection with the left myocommata and is attached wholly to the right side, but regains its median attachment behind the cloaca.

8. Nevertheless the *blade* of the fin always occupies the median line, and, at its junction with the deflected basal part, presents a distinct ridge, which forms the abdominal margin of the *pseudovent.*

9. The *true* (or morphological) *vent* is an oblique elongated opening upon the right side of the cloaca and considerably to the *right* of the median line.

10. But the basal part of the fin underlies this orifice and extends downwards to and slightly across the median line so as to bring

* For a brief discussion of the question as to the morphical values of parts and characters, see my paper,—Intermembral Homologies, Proc. Bot. Soc. Nat. Hist., 1871, vol. xiv.

the blade upon that line, and therefore, although the vent is to the left of the fin, yet,

11. Not only is the true vent invisible from either the right or left side, but the fæces in order wholly to leave the body, must pass to the left from the true vent and escape at a point which is really upon the left of the median line.

12. This complex protection of the vent, in connection with other appearances, suggests that backward progression of the animal is often resorted to.

But we must conclude, with Goodsir, that to "complete the history of the lancelet, an examination of it when alive in seawater must be undertaken. In this way only can certain points in its structure be explained and light be thrown on the economy of one of the most anomalous of the vertebrated animals."

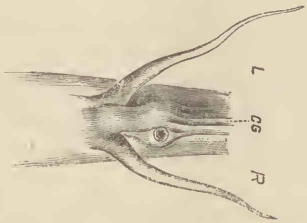

Fig. 7. Cloacal region of *Protopterus annectens*; natural size; drawn from a specimen in the Museum of Comp. Zoology, L the left side; R the right side; CG the caudal groove, a furrow upon the median line which divides the edge of the fin into two thin laminæ.

The vent in Protopterus and Lepidosiren.—Müller's reference to the asymmetrical position of the vent in *Lepidosiren* (Protopterus) *annectens* has been quoted (page 276); Quatrefages follows Müller in comparing it with *Amphioxus*, but as shown in the above figure (which does not differ essentially from the figures and description of other authors),* the structural arrangements are quite unlike, for in *Lepidosiren* and *Protopterus* the vent is a distinct circular orifice wholly upon one side of the median line opening upon a sort of fusiform papilla or raised surface which, however, projects less from the surface of the body than the thick-

* Owen, Linn. Trans. xviii; Bischoff, Ann. Des. Sci. Nat. 3rd series, 14, Peters. Müller's Archiv für Anatomie, 1845; Vander Hoven, Handbook of Zoology, and Gunther's Catalogue of Fishes.

ened fin-base; this latter extends forward to between the roots of the skelea (hinder legs); for some distance behind the vent (in the specimen here figured) the thin border of the fin is in two laminæ with a groove between. The side of the fin-base opposite to the vent projects somewhat like the vent papilla, and all authors agree that the vent opens sometimes upon one and sometimes upon the other side. Without sections of the body at this region and the study of the embryonic condition of the parts one cannot be sure of what is their morphological relation, but they appear as if the vent, a normally median organ, opened itself upon one or the other side of the fin-base and that the two mutually crowded each other a little from the median line; perhaps the blade of the fin is deeper in the young individuals.

In Ceratodus.—In a large specimen of *Ceratodus Forsteri* at the Museum of Comparative Zoology the fin ceases considerably behind the vent, and this is apparently a median opening, although slightly asymmetrical in form, perhaps on account of distortion in the spirit. Günther makes no mention of a peculiarity of this region.

The vent in Myzontes (marsipobranchii).—Whatever may be their precise zoological relationship,* there is no doubt that the *Myzontes* are the group of vertebrates next above *Amphioxus*, and it is therefore desirable to ascertain the character of the vent in the three genera now constituting the group.

In *Myxine glutinosa* the vent is a longitudinal median slit between what might at first seem to be the divided moities of an abdominal fin. I have not as yet made the sections which would probably decide the matter, but am inclined to think that the true fin lies wholly behind the vent, and the slight cutaneous fold which lies in front of and behind it is not in the strictest sense a fin like that which exists in *Amphioxus*.

* Of late years the opinion has gained ground that the peculiarities of *Amphioxus* are such as to entitle it to the rank of a sub-class or class or even sub-kingdom; with this, however, I have never sympathized. I hesitate to express a contrary opinion without more extensive knowledge than I now possess, but it may not be improper to state that last summer (at the Anderson school of Nat. Hist. Penikese Id., Aug., 1873), after a lecture in which I contrasted diagrammatic views of the branchial apparatus in *Amphioxus*, *Myzine*, *Bdellostoma* and *Petromyzon*, Prof. Agassiz announced his belief that these four genera would prove to be the representatives of four groups which he would regard as orders of the class *Myzontes* (or marsipobranchs). This opinion might and will hereafter, be confirmed by many other considerations which I now refrain from presenting.

In *Bdellostoma polytrema* the body is deeper in front of than behind the vent, which is thus caused to look backward as well as ventrad, between two folds which seem to be equal or if unequal, not so in any uniform manner; all the specimens examined by me, (from the Mus. Comp. Zool.) are in poor condition.

IN PETROMYZON.—It so happened that the three representatives of this genus first examined by me were a large *P. Americanus* ♀, and two small specimens from Cayuga Lake of a species which I do not yet regard as satisfactorily determined; the first named presented a sort of notch in the right half of the body just at the vent, which gave the latter a decided *sinister* aspect; the two smaller specimens were a ♀ and ♂; and in one the vent looked to the right, in the other to the left; and I imagined this peculiarity might relate to convenience in copulation; but of seventeen specimens of *P. Americanus* since examined, no such condition of things exists; a much larger number of specimens must be examined before any generalization can be made. I am inclined to think, however, that the very early larvæ of the *Myzontes* may present an *Amphioxus*-like structure of the cloaca.

THE VENT IN THE LARVÆ OF RANA PIPIENS.—An examination of fifteen larvæ of *Rana pipiens*, taken in the same stream in June, 1873, showed that in every case there was a decided asymmetry in the cloacal region. The median caudal fin is continuous from the tip of the tail to the abdominal integument. In the specimens with small skelea (hind-legs) the connection between the abdomi-

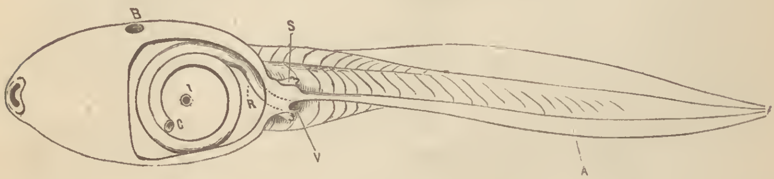

Fig. 8. A larva of *Rana pipiens*, partly dissected, seen from below; B, the persistent left branchial orifice; most of the intestinal coil has been removed. I being the cut end of the pyloric portion, and C the cut end of the last coil; R the *rectum* lying close against the left side of the abdomen, before crossing to the median line to open at V the vent between the two moieties of the fin (A), of which the right is much thinner; S, the left skelos or hind leg.

nal skin and the fin proper is a broad fold, which becomes reduced, apparently by absorption, as the skelea increase, until in those farthest advanced it forms a mere ridge upon the middle line.

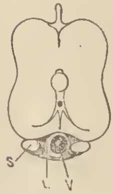

Fig. 9. A transverse section of the root of the tail of the same larva of *Rana pipiens* made in a plane indicated by the line S in fig. 8. S, the cut end of the left skelos; L, the thicker left moiety of the fin which is continuous with the caudal fin; the thinner right moiety ceasing at a point just behind the section.

Now the vent seems to divide this into two laminæ of which the left is always the larger and thicker, while that upon the right of the orifice is thinner and in the specimens with largest skelea, has nearly disappeared; the vent must therefore be described as wholly or in part on the *right* of the median fin in these larvæ.

But the fact that the vent is to the right of the caudal fin, and that the latter is not as is usual among vertebrates, wholly interrupted by it, does not necessarily enable us to say that the vent is *dextrad of the median line;* on the contrary, I am inclined to think that the vent is really upon the median line, in the larva as in the adult, and that the laminæ of the anal fin are divaricated unequally according to their different thickness, giving the apparently lateral position of the opening as already described.

We ought perhaps to discriminate between the *real vent* as it exists in *both* stages of growth and the orifice of the short tube* between the deciduous laminæ, which orifice certainly looks toward the right.

It is obvious that a more extended examination should be made of the larvæ of different Batrachians; and the purpose of this paper is mainly to call attention to a peculiarity which, so far as I am aware, has not before been observed.

The condition of things is more like that of *Bdellostoma* than *Amphioxus;* and a curious contrast exists, from the fact that while

* Alluded to by Owen (C. A. V., vol. i, 623) as the "tegumentary and transitory cloacal canal at the fore-part of the subcaudal fin."

the latter form gains a caudal prolongation beyond the vent, *Rana* loses the tail in the course of development; and the adult cloacal aspect is not unlike that figured by Kowalewsky in the *Amphioxus* of sixteen hours.

WEIGHTS AND MEASUREMENTS (IN GRAMS AND MILLIMETERS) OF LARVÆ OF RANA PIPIENS, MADE WHILE SPECIMENS WERE FRESH, JUNE 16, 1873.

No.	Weight.	Length of Skelea (hind legs).	Body (muzzle to vent).	Tail (from vent).	Total length.	Alimentary canal from mouth to bight of intestine.	From bight to vent.	Total.
1	,013.	.003,5	.041,	.076,	.117,			
2	,013.	.004,	.041,	.074,	.115,			
3	,015.	.004,	.037,	.076,	.113,	,413,	,350,	.763,
4	,016.	.004,	.042,	.076,	.118,	,500,	,365.	.865,
5	,015.	.005,	.042,	.078,	.120,			
6	,013.	.006,	.041,	.076,	.117,			
7	,014.	.008,	.041,	.080,	.121,			
8	,020.	.012,	.046,	.086,	.132,			
9	,019.	.013,	.043,	.087,	.130,	,465,	,380,	.845,
10	,022.	.037,	.045,	.097,	.142,			
11	,021.	.038,	.048,	.098,	.146,			
12	,020.	.040,	.046,	.098,	.144,			
13	,026.	.042,	.047,	.089,	.136,	,760,	,513,	1.273,
14	,028.	.046,	.045,	.100,	.145,			
15	,025.	.051,	.046,	.091,	.137,			

Having arranged the specimens according to the increase in length of the skelea, we see:

1. A general increase in the weight and total length; and, with the four measurements given, in the length of the alimentary canal; but none of these increments are constant.

2. The skelea of 10 are nearly three times as long as those of 9; but the increments of length and weight of body are gradual.

3. The comparison of 13 with 9 indicates that the shortening of the alimentary canal, which is said to occur at a later stage,* has not yet commenced.

* Owen, C. A. V., i, 624.

ADDENDUM.—Through the kindness of Prof. Theodore Gill I have to-day (April 29, 1874) received a copy of Stieda's "Studien uber Amphioxus lanceolatus," read before l'Academic imp. des Sciences de St. Petersbourg, Sept. 5, 1872, and published in March, 1873; its presentation and publication thus antedating those of my paper by about a year.*

Although the foregoing paper was already in type, room was kindly made for the present note respecting Stieda's paper. It is chiefly histological, with historical and critical remarks; embracing only seventy pages, and yet touching upon the whole structure it is necessarily very brief in many respects.

Of the twenty-five figures, seven are magnified sections of the entire animal, at the following points: in front of the mouth, through the mouth, through the anterior part of the respiratory cavity, through its posterior part, at the vent and behind the vent. A review of most of the points of general structure must be deferred to another occasion; in some respects my observations confirm his, in others I am not prepared to make a positive assertion, but in a few I am sure he is incorrect. The only reference to the position of the vent is on page 5:—"Hinter dem Porus abdominalis, im Bereich der eigentlichen Afterflosse, befindet sich, an der linken Seite, die nur kleine afteröffnung." (Behind the abdominal pore, in the region (line ?) of the true anal fin, lies the very small anal opening).

I give a copy of the lower half of his figure representing the section at the vent; it is *reversed* for convenience of comparison with my own, since his is as if viewed from in front, while all mine are as if viewed from behind.

With regard to the minute structure of the intestine which he describes as presenting in addition to the peritoneum, an outer thinner coat, a middle or thicker coat, and an inner or epithelial layer which, at the vent, gradually merges into the ordinary cuticle, Prof. Stieda's reputation as an histologist deters me from positive counterstatement at this time; but as to the morphological relations of parts to each other and to the middle line, I am obliged

*Foreign scientists will hardly be able to believe that a memoir upon so interesting a subject, and in a periodical which doubtless is at once received in every university library of Europe, should so long be unknown to a worker in the same field here and even then be first learned of through the "scientific record" of a popular magazine, "Harpers' Monthly;" but my American brethren will understand the case, for they know that, excepting only at Boston, New York, Philadelphia and Washington, they are always liable to do over what has been already done a year or more before, and to rediscover things which are already familiar.

to differ with him, and trust that he will, upon reception of my paper, reëxamine this point, as I shall this and others in the light of his researches.

I am enabled to offer the following additions to the bibliography from the complete list of works at the end of Stieda's paper.

Costa, Cenni zoologici ossia descrizione sommaria di talune specie nuove di animali. Napoli, 1834.
Notice sur le Branchiostome, comptes rendus T., xiii, p. 873, 1841.
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Frammenti di Anatomia comparata, Fascic. I, Sporia e Notomia del Branchiostomum lubricum. Napoli, 1843 fol.
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Hoven, Verzameling van berigten over Amphioxus l. Tijdschrift voor natürl. Geschiedenis, D. viii (2 Afd.), p. 73, 1841.
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Martino, Sull' anatomia del Branchiostoma l. Giornale dell Instituto Lombard, T. vii, p. 172, 95, Milano, 1846.
Wilh. Müller, Beobacht, des pathol. Instituts zu Jena, Spec. Th., Reike I. Ueber den Ban der Chorda dorsalis. In der Jenaischen Zeitschrift f. Med. w. Naturw. Bd. vi, p. 287, 1867.
Reichert, zur Anat. des Branchiostoma l, Reichert's Archiv, 1870, p. 755.

Fig. 10 (copied from Stieda, Taf. 2, fig. 9; reversed, and cut light on a dark ground.) This is to be compared with my figure D, fig. 6.

On the Composition of the Carpus in Dogs. By B. G. Wilder, of Ithaca, N. Y.

In a paper "On the composition of the carpus of the dog,"* Prof. Flower describes and figures the right carpus of a dog about six weeks old in which the "so-called *scapho-lunar* bone, though well ossified consists not only of a perfectly distinct *scaphoid* and *lunar* but also of a third piece, evidently corresponding to the *os centrale* of the typical carpus," p. 64; and regards this as "proving that in the dog at least neither the *radiale* (scaphoid), *intermedium* (lunar), nor the *centrale* are suppressed, but they are all developed independently and afterwards coalesce to form the so-called scapho-lunar bone."

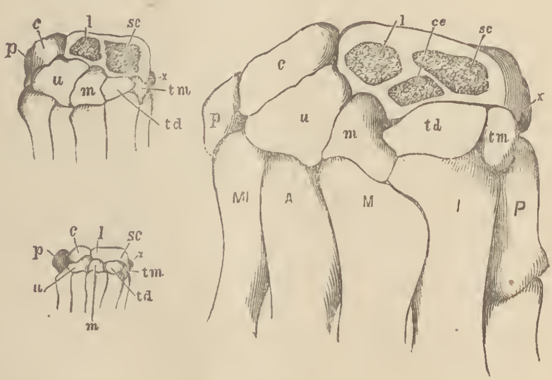

Fig. 1. The right carpus of an Asiatic lion, seven months old (largest figure), of a shepherd pup, and of a new-born English black and tan rat terrier (smallest figure); all are drawn from above and of natural size. The lettering is uniform. P. Pollex; I, Index; M, Medius; A, Annularis; Mi, Minimus. *p, pisiform; x, radial sesamoid,* a cartilaginous nodule attached to the radial border of the scaphoid; *sc,* scaphoid or *radiale; l,* lunar or intermedium; *ce, centrale; c,* cuneiform or *ulnare; tm,* trapezium; *td,* trapezoid; *m,* magnum; *u,* unciform.

Wishing to confirm the above statements upon other specimens I examined the parts in question upon two young dogs and a young Asiatic lion, carefully removing thin slices of the cartilaginous *carpi;* the figures show that:

1. In this lion seven months old, the *scapho-lunar* is a single cartilage, containing three centres of ossification, which undoubtedly

* Read at the British Association Aug. 7, 1871, and published in the Journal of Anatomy and Physiology, Nov., 1871, page 62.

correspond to the three elements, *scaphoid*, *lunar* and *centrale* and which would probably, at a later age, coalesce into one bone.

2. In the shepherd pup (age unknown) the single scapho-lunar cartilage contains but two ossifications; the radial one, however, is so large as to allow the supposition that it represents the already coalesced *scaphoid* and *centrale*.

3. In the new-born terrier, the cartilage presents no trace of ossific deposit, though sections were made in all directions; it is moreover single and undivided, as in the other cases, but as it articulates with the *cuneiform* and *unciform* on the one side, with the *trapezium* on the other, and with the *magnum* and *trapezoid* by its distal border, it must be held to represent the *scapho-lunar* just as much as do the partly ossified cartilages in the other two cases.

A similar appearance is presented in a fœtal gray wolf the mother of which died four days before the expected time of birth, and in a young red fox, whose eyes were just opening.

From the above facts we may conclude that:

1. The carpal element *centrale* which Gegenbaur holds to enter into the composition of the typical carpus, but which he found distinct only in *Quadrumana* and in some *Rodentia* and *Insectivora*,* exists as a separate centre of ossification in a young lion, and is probably represented in the young shepherd dog and the terrier; as in the young dog described by Flower.

2. But in the three cases described by me the cartilages of these three elements are probably *connate*, and the osseous formations *coalesce;* while in Flower's example there seems to have been neither connascence nor coalescence of either cartilage or bone; for even if we suppose that in that case a single cartilage afterward divided, yet it is certain that no such change occurs in the lion; and since the shepherd pup presents only two ossifications, we must either conclude, as above that a coalescence of *centrale* with *scaphoid* has occurred, or that in this kind of dog the *centrale* is wanting.

3. It is easier to imagine that the *Carnivora* may vary among themselves and that the dogs in particular, which in so many other respects present striking differences, may vary in regard to the manner of formation of carpal elements and even perhaps as to their existence.

4. It is evident that any generalization respecting dogs should specify the breed, age and sex.

* Carpus und Tarsus, p. 50.

Present Aspect of the Question of Intermembral Homologies. By B. G. Wilder, of Ithaca, N. Y.

Attention is called to the apparent unconsciousness of English and Continental anatomists that there exists, chiefly in the United States, an opinion respecting the homology of the anterior and posterior limbs, totally at variance with their own; and it is suggested that if each party will yield a part of its present position, a reconciliation may be effected. I hope, by means of embryology and the study of *Amphioxus* to demonstrate the existence of a true "meketropy" (antero-posterior symmetry) within the vertebrate branch. I hold that if the same methods of comparison and of deduction which are employed in studying the limbs of different animals are used in comparing the anterior and posterior limbs of the same animal, there can be no escape from the conclusion that the anterior digit (thumb) is the true homologue of the posterior dactyl (little toe); and that the little finger is in like manner the true homologue of the great toe. To this opinion are now inclined the following anatomists: Wyman, Agassiz, Dana, Coues, Foltz, and the writer; all others now living, and those who have written on the subject since 1774, hold the contrary opinion.*

Variation in the Condition of the External Sense Organs in Fœtal Pigs of the same Litter. By Burt G. Wilder, of Ithaca, N. Y.

In comparing fœtal mammals of unknown age, it is natural to estimate their relative age, partly according to the degree of closure of the lids, and the direction of the pinnæ; since it is known that the former are at first mere folds above and below the uncovered balls, which are gradually covered by them; and that the pinnæ are first formed as little triangular folds behind the meatus, which at first project directly forward, and then, as

*A historical sketch of the question, with a full bibliography is given in a paper lately published by me, Intermembral Homologies; Proc. Bost. Soc. Nat. Hist., 1871.

they increase in size, gradually rise to the erect position, and only later are retroverted upon the neck.

While forming a collection of fœtal pigs at the large *abattoir* of J. P. Squiers in East Cambridge, Mass., during the summer of 1872, I compared the individuals of the same litter, carefully avoiding any artificial displacement of the parts.

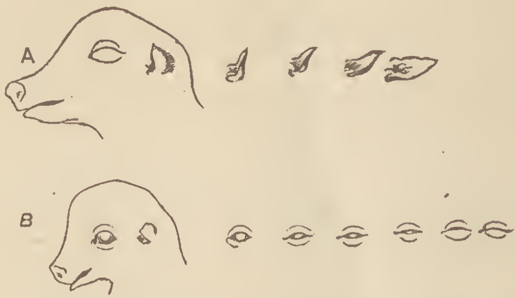

Fig. 1. A. Head and series of pinnae from fœtal pigs (Nos. 296 to 300, M. C. Z.) of the same litter.
B. Head and series of eyes from fœtal pigs of the same litter (Nos. 303 to 309).

In the five pigs of the same litter * having an average length from vertex to anus of ·067, mm. and an average weight of ,017·5 grams, the direction of the pinna ranges from a slight but decided *anteversion*, to an almost complete *retroversion*. Figure 1, A.

In the seven pigs of another litter † averaging ·040, in length, the lids range from folds covering slightly the upper and lower margins of the ball, to complete closure. The sizes and degrees of closure do not exactly coincide. It would be interesting in both these cases to know the relative position of the individuals in the mother's uterine cornua ; but these facts indicate the need of far more extended comparisons than have been made.

I have also observed some striking changes in the form of the nostril in fœtal pigs ; it is in its earliest condition a notch, whose lower margins then come together forming a hole ; this elongates laterally and is indented above so as to become more and more crescentic ; but at or before birth the circular form is regained and retained through life ; illustrations of these changes will be presented upon another occasion.

* Marked 296 to 300 on the Catalogue of Neurology and Embryology of Domesticated Animals at the Museum of Comparative Zoology, Cambridge, Mass.

† Marked 303 to 309 in the same catalogue.

THE PECTORAL MUSCLES OF MAMMALIA. By BURT G. WILDER, of Ithaca, N. Y.

THE following is a provisional abstract of results based upon the dissection of the pectoral group of muscles of twenty-two genera of mammals, representing all of the usually recognized orders, excepting the *Solipedia*, *Hyracoidea*, *Cetacea* and *Sirenia*.

Before publishing in detail and with figures from the drawings* which I have made of all the dissections, I wish to examine several other genera (particularly *Lutra*, *Phoca*, *Delphinus*) and also other individuals or species of the species and genera here enumerated.

Homo,	Man.
Troglodytes,	Chimpanzee.
Pithecus,	Orang.
Macacus,	Monkey.
Galago,	Lemur.
Felis catus,	Cat.
Felis leo,	Lion.
Canis occidentalis,	Gray wolf.
Canis familiaris (see next paper),	Dog.
Ursus,	Bear.
Procyon,	Raccoon.
Putorius,	Weasel.
Mephitis,	Skunk.
Scalops,	Mole.
Condylura,	Star-nosed mole.
Pteropus,	Bat.
Bradypus,	Sloth.
Myrmecophaga,	Ant-eater.
Cyclothurus,	Little ant-eater.
Dasypus,	Armadillo.
Mus,	Rat.
Arctomys,	Woodchuck.
Bos,	Cow.
Cervus,	Deer.

*These drawings were shown at the meeting.

The investigation began in an effort to reconcile conflicting statements respecting the existence of the *Pectoralis minor* in the cat and some other Mammalia. Strauss-Durckheim denies its presence in the cat; and Cuvier and Meckel in some other *carnivora;* while others (Haughton), mention its presence without comment.

In nearly all Mammalia the main pectoral mass is naturally separable into an outer and an inner layer; these are respectively homologous with the *Pectoralis major* and *P. minor* of man; for convenience and in order to avoid the ascription of less constant attributes than relative position, they may be called respectively *ectopectoralis* and *entopectoralis;* as the buttock muscles are now called *ecto-*, *meso-* and *ento-glutæus*.

The usual origin of the *ectopectoralis* is the middle line of the sternum, and a median raphé anterior to it; its insertion is into the outer tuberosity of the humerus, and distad therefrom upon the same bone; the usual origin of the *entopectoralis* is from the anterior angles of the costal cartilages and sternum, and from the contiguous borders of these parts; its insertion is upon the outer humeral tuberosity and outer margin of the bicipital groove, covered more or less by the insertion of the *ectopectoral.* But there is nearly always a small but distinct tendon which is attached to the *coracoid process* or to the tubercle representing it in many quadrupeds; this is interesting in view of the fact that in *Quadrumana* often, and in man usually (but by no means so generally as is supposed), the entire attachment upon one or both sides is upon the coracoid process.

This coracoid insertion is perfectly distinct in all the *Canidæ* and *Felidæ* dissected by me; but Strauss-Durckheim, not recognizing the *entopectoral* as such on account of its great size, describes the tendon of the *sterno-trochiterien* in the cat (which he regarded as a dismemberment of the *P. major*, as sending a slip to the *supra spinatus;* teleologically it might as well be so, but morphologically there is every reason for its attachment to the rudimentary coracoid. The above, by the way, is the only error in description which I have found in that admirable monograph; but errors of homological interpretation are by no means uncommon.

The *ectopectoralis* tends to separate, especially anteriorly, into superimposed laminæ; while the *entopectoralis* tends to form fasciculi, corresponding to the number of costo-sternal articulations involved in its origin.

The *ectopectoralis* has generally an outward direction, and acts therefore as an *adductor humeri;* the *entopectoralis* has an oblique direction from within, forward and outward, and acts chiefly as a *retractor omou* (retractor of the shoulder). The *entopectoralis* is generally much the larger, the exceptions being man, the higher quadrumana, the bear, the skunk and the bat.

In addition to the main pectoral mass, there are generally found one, two or more smaller muscular elements, whose relations are variable with the thorax and armus, with the main pectoral mass, and with certain other muscles (*latissimus dorsi*, *dermo humeralis*, *rectus abdominus* and *obliquus externus*. It is probable that these are differentiated portions of the main pectoral mass, but a more extended comparison is needed.

There is need of more accuracy in the dissection, delineation and description of muscles; since at present there is great confusion respecting the nature of true muscular integers, and the basis of muscular homologies; as a provisional opinion, it may be stated that size, form and function are much less reliable than origin, relative position and insertion, and that origin is the most reliable basis for muscular homology.

The most profitable work will be the careful comparison of *nearly allied species and genera.* At present, so little are we agreed upon the basis of arrangement that each new "myology" is in great part useless in the present and a burden upon the future; in fact, we should do well to avoid publication of dissections made of a single specimen of a species, and a single species of a genus; and of all dissections by *beginners.* My own experience has proved the risk of fallacies resulting from the too sparing or too persistent use of the knife, and the overlooking of points which may have no teleological importance, but great morphological significance.

Variation in the Pectoral Muscles of Domestic Dogs. By Burt G. Wilder, of Ithaca, N. Y.

ABSTRACT.

I have made drawings* of my own dissections of the pectoral muscles in nine breeds of domestic dogs (*Canis familiaris*), as follows: English terrier, skye terrier, spaniel, greyhound, spitz or Pomeranian, setter, Newfoundland, St. Bernard and shepherd. Like that upon the brains of dogs, this investigation was begun in order to ascertain whether among our domestic dogs there exist internal and structural differences comparable with those of habit and external appearance, which are greater than would be held to characterize distinct species of wild animals.†

Deferring publication in full until a greater number of breeds have been examined,‡ and until the general homology of the *pectorales* is determined, I would say here that so far there has been great uniformity in the main pectoral muscles, *ectopectoral* and *entopectoral;* certainly no such differences as might be inferred from the external appearances of the breeds. Among the minor outlying members of the group referred to in the preceding paper, there is some variation, but usually not more than might be attributed to mere individual peculiarity.

The stomachs and cæca of these and several other dogs are preserved, inflated, in either Ithaca or Cambridge. I hope at some time to present superposed outlines of these for exact comparison.

* These were shown at the meeting.

† Yet as remarked on page 242, even the child recognizes them all as *dogs*.

‡ A Chinese dog and a Mexican (Chihuahua) dog are among the specimens awaiting dissection.